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DEVELOPMENTAL ANATOMY OF SEEDLING OF JATROPHA CORDATA[1]

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The anatomical literature of the Euphorbiaceae is well summarized, up to 1902, by Gaucher (5) and, up to 1908, by Solereder (16). The more important papers which have appeared since 1908 include the work of Reiche (12), Swingle (19), Ferry (4), Helm (7, 8), Santos (14), Milanez (10), and Scott (15) Anatomical research done on the roots and stems of Euphorbes, reported in this literature, is principally concerned with the formation of laticiferous, tanniferous, and resiniferous cells or tubes; crystalliferous and granular cell inclusions; cork; collenchyma; fibers and sclerified cells; trichomes, and wood structure. Many problems, including the anatomy of the hypocotyl, studies on the time and place of tissue origin, and direction of tissue differentiation have been neglected. Apparently no one has investigated the entire stem, hypocotyl, and root anatomy of any species of the Euphorbiaceae

MATERIAL AND METHODS

Jatropha is a large genus of the Euphorbiaceae closely related to *Hevea*, *Manihot*, and *Ricinus* (17) and is composed of about 150 species of trees, shrubs, and herbs. Its distribution is mostly tropical and subtropical in both hemispheres. In North America, *Jatropha cordata* (Orteg.) Muell. is found in Mexico on both sides of the Gulf of California, in the mountains of Baja California, and through Sonora, southern Chihauhau, and Sinaloa to Jalisco. When mature, this species has the growth form of a small tree 20–25 feet high with the superficial appearance of a shrub. A stem of this semi-woody plant 5 inches in diameter can easily be cut in two with one forceful slash of a machete.

Work was begun on the problem in the summer of 1939 at the Desert Laboratory of the Carnegie Institution of Washington at Tucson, Arizona. Seeds, collected near Hermosillo, Sonora, Mexico, were planted one-half inch below the soil level in pots in the greenhouse of the Desert Laboratory. Mature embryos, as well as seedlings of various ages (4, 7, 21, 41, and 75 days old), were preserved in Stover's fluid (3 cc. formalin, 30 cc. ethyl alcohol (95%), 67 cc. distilled water). During the summer, serial sections of the root, hypocotyl, and stem were cut and stained according to a safranin and fast green schedule modified from Johansen's (9).

GENERAL OBSERVATIONS

The root system of the seedling consists of one primary and four adventitious roots, all five of which are similar in size, anatomy, relative position, and time of origin. The primary root differentiates directly downward from the lower end of the hypocotyl. The four procambial strands of the hypocotyl coalesce about

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[1] **Papers from the Department of Botany, The Ohio State University, No. 443.**

50 μ above the collet, resulting in a core of pith and a cylinder of procambium which is continuous from the hypocotyl through the primary root. The four adventitious root primordia originate at the angles of an imaginary square, the corners of which are the points of junction of the four provascular strands of the hypocotyl.

During the first day or two after planting the seed, the adventitious roots remain imbedded in the cortex of the enlarged hypocotyl base (fig. 5). On the third day they push through the epidermis, and by the fourth day the adventitious roots and the primary root are all about 18 mm. long and equal in diameter. From this time on the five roots enlarge and elongate at about the same rate and are comparable in structure. The initiation of secondary roots does not occur until about the seventh day. These may appear first along the lower half of the five principal roots or nearer the base of the hypocotyl.

The straight hypocotyl of the embryo is about 2 mm. long. By the end of the fourth day after planting, when the cotyledons and endosperm emerge from the seed coat, the hypocotyl is about 18 mm. long. On the seventh day it reaches a maximum length of 10–13 cm., at which time the green cotyledons are free from the endosperm in which they were imbedded. The cotyledons bear the same relationship to the endosperm as in *Ricinus communis*. From the seventh day until the plant is two and one-half months old, the hypocotyl continues enlarging, especially at the basal end.

The hypocotyl of *Jatropha cordata* should not be considered a portion of the stem containing the transition region, but rather an organ of the plant possessing a developmental anatomy peculiar to it alone. In the stem-hypocotyl transition, the many leaf traces anastomose, forming four "synthetic bundles"[2] which alternate with the four cotyledon traces. In the upper one-half inch of the hypocotyl, the synthetic bundles anastomose with the cotyledon traces, resulting in four vascular bundles which extend through the organ (fig. 12) to within about 2 mm. of its base, where they coalesce.

The plumule is composed of one node, about 10 μ long, and the apical meristem which extends about 5 μ beyond it. No procambial strands are discernible. During the first four days, the stem elongates to about 120 μ and is composed of two nodes and the meristem which extends about 5 μ beyond the second node. One central and two lateral procambial strands become differentiated in each of the leaf primordia.

By the end of the first week, the stem is about 1 mm. long and six leaf primordia have become organized. The oldest primordium gradually becomes isolated from the five lying above it and from the cotyledonary node by the elongation of adjacent internodes. One new leaf primordium becomes differentiated each week until the plant is four months old or older. Consistently, the apical meristem extends 10 μ beyond the five youngest leaf primordia which remain closely aggregated in the first millimeter of the stem tip. As each successive primordium is organized, the oldest one becomes separated from the five above it by elongation of the intervening internode.

The procambium, which becomes organized some time within the first four days, is distinguishable as a complete ring of meristematic cells at the youngest node of the stem tip. The arc of procambial tissue extending down from the youngest leaf primordium makes up one-half the ring. Three provascular strands are observable in this arc as groups of smaller cells. The remainder of the procambial ring consists of an arc of small meristematic cells similar to and continuous with those of the apical meristem. At the time of differentiation, the cells of the ring show no radial seriation.

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[2] As used by Priestley (11), a synthetic bundle is one "formed by the coalescence of the downward extension of the bundles from higher leaves."

Although there is some variation, especially in the first few internodes, most of the vascular bundles appear to extend through five internodes before anastomosing with other bundles.

In figures 1–4 the general pattern of growth by tissues in the root, hypocotyl, and stem has been recorded. From these graphs it may be inferred that the growth pattern is different for each of the three organs. A comparison of figures 2 and 3 indicates that the growth pattern is similar throughout the hypocotyl, except that growth is more than twice as rapid in the basal as in the upper end. An accurate interpretation of these graphs is dependent upon a knowledge of changes occurring in the various growing tissues. These observations are recorded in the following pages.

EPIDERMIS

The epidermis of the embryo is differentiated from a point about 370 μ from the root apex, through the hypocotyl, to within 10 μ of the stem apex. The thin-walled cells, dense with cytoplasm and radially elongated, divide only anticlinally. During the first four days the epidermal cells of the hypocotyl and most of the root vacuolate, elongate, and enlarge in the tangential direction. Concomitantly anticlinal divisions become less frequent. Cells of the hypocotyl frequently increase in length 4–6 times and double in cross sectional area. The same events occur in the stem as each successive internode elongates.

Ephemeral root hairs differentiate during the second or third day, about 9 mm. from the root apex. The nucleus frequently migrates into these protrusions, some of which become 225 μ long. By the end of the fourth day, many of these first-formed root hairs collapse and begin disintegrating.

A very thin cuticle covers the hypocotyl and plumule of the embryo. By the sixth week it forms a layer which varies in thickness from 1 μ at the stem tip and at the base of the hypocotyl to 6 μ in the mid portions of the shoot. At the same time that the cuticle is being formed, secondary epidermal cell walls form and become 1 μ thick by the middle of the third month.

Stomates differentiate in the epidermis of the embryo covering the basal third of the hypocotyl, and by the end of the third week they are present throughout the lower three-fourths of the epidermal cylinder. No stomates were observed in the epidermis of either the stem or the roots.

Sometime between the first and third weeks, the epidermis and some of the underlying layers of phellem begin splitting longitudinally in places throughout the lower 7 cm. of the hypocotyl. These breaks deepen and lengthen through the remainder of the hypocotyl, root, and stem as the organs increase in diameter. In the portions of the root one month old or older, the epidermis, hypodermis, cortical parenchyma, and outer layers of phellem have split (fig. 11). The crushed and disintegrating epidermal cells lie in broken sheets adhering to the ridges of bark. Sometime after the sixth week, the epidermis and the underlying layers of cork at the base of the stem begin splitting (fig. 13).

HYPODERMIS

The hypodermis of the embryo hypocotyl can be distinguished from the cortical parenchyma on the basis of the cell size, shape, contents, and staining properties but it does not differentiate in the root and plumule until about the fourth day. From that time on it is distinct throughout the plant from a point 10 μ from the stem apex to within 370 μ of the root apex. Although the tissue consists mostly of one layer of square or radially elongated cells, occasionally two and rarely more layers were observed in older roots.

Cessation of rapid anticlinal divisions soon after differentiation is followed by a three-day period of rapid vacuolation and tangential enlargement during which time the cells often triple in length.

In the root, during the first four days, the walls adjacent to the epidermis, the outer portion of the radial walls, and the collenchymatous thickenings which form between the epidermis and hypodermis undergo a chemical change, staining red with safranin. By the end of the first week the entire radial walls of many cells stain red. Collenchymatous thickenings begin forming in the intercellular spaces along the hypodermis-cortical parenchyma junction soon after the first week.

About the fourth day, periclinial divisions initiate a cork cambium in the hypodermis at the base of the hypocotyl. By the third week the cambium is present throughout the hypocotyl (fig. 12); after this time differentiation proceeds slowly, acropetally into the stem. When the plant is two and one-half months old, the hypodermis is uniseriate in the upper half of the stem while in the lower half there is one additional layer of periderm in each successively lower internode. At the collet there are eight layers and at the base of the hypocotyl, twelve layers. The rectangular, tangentially elongated cells of the periderm lie tightly compacted in radial seriation. Secondary cellulose walls, about 1 μ thick, are deposited inside the suberized primary walls of the phellem. The thin-walled cells of the phellogen are similar to those of the phellem in tangential dimension but only half as great in radial dimension. The phelloderm, which represents the enlarged centrad half of the original layer of hypodermis, is composed of one layer of cells comparable in size and vacuolation to those of the phellem but with thin, cellulose primary walls. After phellogen initiation, the cells of the phellogen and phelloderm slowly increase in tangential dimension except in the basal inch of the hypocotyl where the process is very rapid. When the cells are about double their original tangential dimension, they divide anticlinally. Consequently anticlinal divisions are most numerous in the basal inch of the hypocotyl.

CORTICAL PARENCHYMA

The cortical parenchyma of the embryo extends throughout the hypocotyl and to within 320 μ of the root apex. Strictly speaking, the tissue in the root has a definite inner boundary but an approximate outer one, since the endodermis is differentiated in the embryo stage but the hypodermis is not. In the root the number of cell layers (twelve) remain constant until disintegration of the tissue, except in the apical 1 mm. of the primordia where the number has not yet reached twelve. The cells of the eight inner layers are in radial seriation with the actively dividing endodermal cells (fig. 7). Periclinal as well as anticlinal divisions continue longest in those layers nearest the endodermis. Relatively large quantities of starch are present in the cells.

In the hypocotyl, anticlinal and periclinal divisions are restricted to areas adjacent to the phloem for the first 2–3 weeks, after which they spread radially through the cortical parenchyma in the basal inch of the organ and then gradually, acropetally. Divisions are at all times more numerous in the lower inch of the hypocotyl.

During the first week the cells of the cortical parenchyma in the root primordia and hypocotyl undergo tremendous enlargement at which time they lose their decided tangential elongation and become more or less circular in cross section.

EXPLANATION OF PLATE I

FIG. 1. Graph showing relative widths of the various tissues along the radius during differentiation and maturation in the oldest portion of the root.

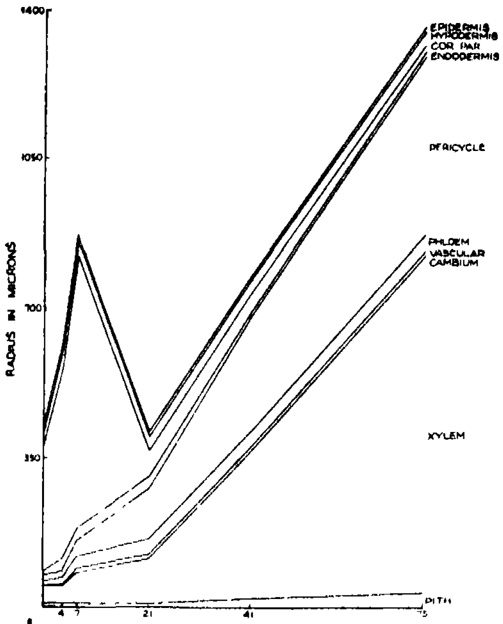
FIG. 2. Graph showing relative widths of the various tissues along the radius during differentiation and maturation in the basal end of the hypocotyl.

FIG. 3. Graph showing relative widths of the various tissues along the radius during differentiation and maturation in the top end of the hypocotyl.

FIG. 4. Graph showing relative widths of the various tissues along the radius during differentiation and maturation in the oldest portion of the stem.

Anatomy of Jathropa cordata
Richard A. Popham

PLATE I



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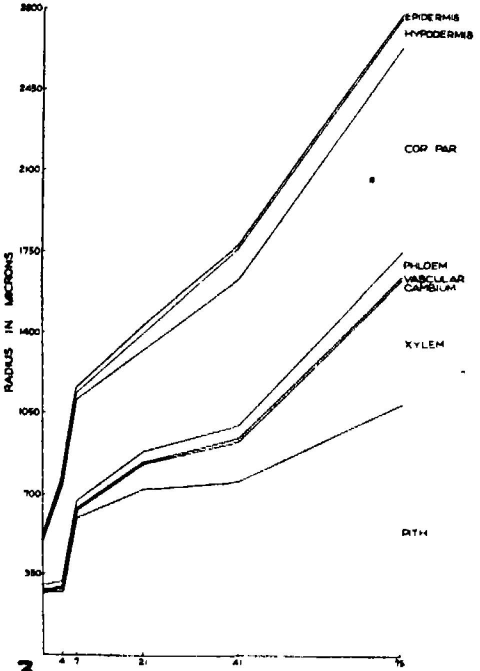

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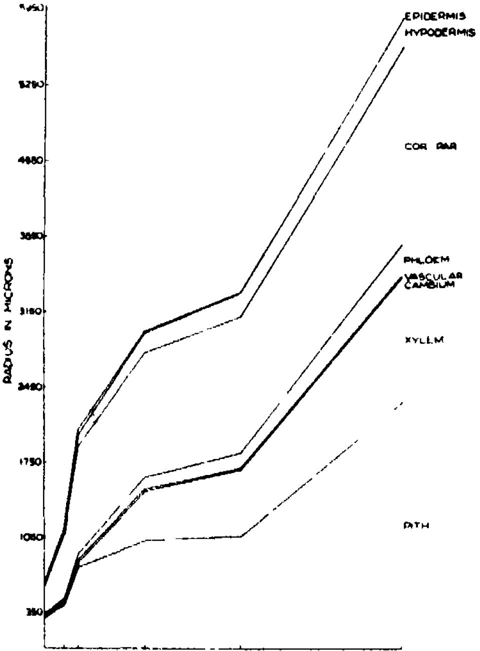

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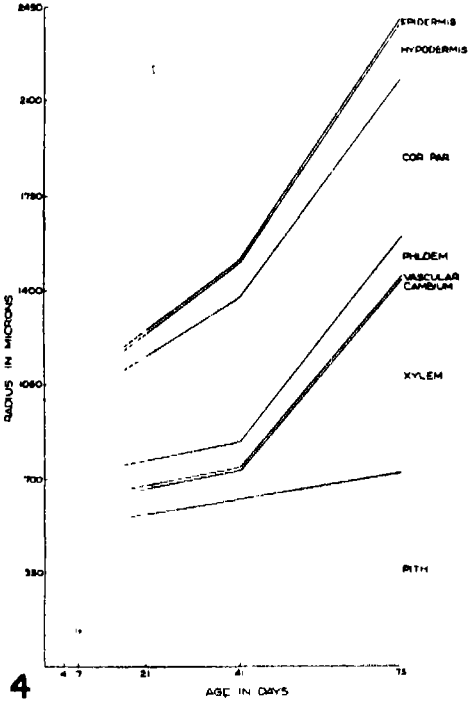

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Many cells, especially in the hypocotyl, increase in cross sectional area 10–15 times and in length 1–4 times.

Between the first and third weeks, the cortical parenchyma in the oldest portions of the root undergoes a collapse, and cell disintegration begins (fig. 10). The radial dimension of the tissue decreases about 80 per cent during this two-week period, and by the middle of the third month only fragmentary remnants of the disintegration products of the protoplasm and cell walls remain (fig. 11).

A few larger, thicker-walled, mostly empty cells which become filled with latex during the first 3–4 days, differentiate adjacent to the phloem in the hypocotyl; they appear in the stem soon after differentiation of the cortical parenchyma. The cortical parenchyma of the stem becomes differentiated at the youngest node, about 10 μ from the stem apex. The small cells are tightly compacted and divide in all planes, although most frequently periclincally. At the time of internode elongation, the cortical parenchyma of the stem becomes distinctly divided into two concentric rings of tissue (fig 13). Divisions cease in the outer layers of cells, which begin enlarging and elongating tangentially, but centrad to this outer ring and interspersed among the enlarging parenchyma and latex cells, strands of small, dividing cells persist. Similar groups of dividing cells appear in the hypocotyl at about the end of the first week. During the second week, beginning at the base of the hypocotyl and proceeding acropetally, the larger, scattered cells in these strands begin forming secondary cellulose walls. Differentiation of fibers from parenchyma cells proceeds acropetally through the hypocotyl and stem at a rapid rate. Accompanying the differentiation of fibers is an increase in the number and thickness of the laminations deposited inside their primary walls. By the middle of the third month, the secondary walls of fibers in the basal inch of the hypocotyl are about 11 μ thick while in the rest of the hypocotyl and older portions of the stem, they are 7–8 μ thick.

The most recently differentiated fibers in the lower inch of the two and one-half months old hypocotyl are mostly two or more times larger in cross sectional area than any in the shoot. Beginning with the origin of the fiber initials, the enlargement and division of the intervening parenchyma cells results in further separation of the groups of fibers from the phloem. Since the rapidity of cell division and the degree of cell enlargement are greater in the basal inch of the hypocotyl, cortical fiber groups here become farthest separated from the phloem.

Chloroplasts appear in the cortical parenchyma of the hypocotyl and stem during the period of rapid cell enlargement. They are most abundant in the cells nearest the hypodermis. During the week following rapid internode elongation, collenchymatous thickenings are initiated in the two or three layers of tightly compacted cells of the stem adjacent to the hypodermis.

ENDODERMIS OF ROOT[3]

In the embryo, the endodermis forms a cylinder of tangentially elongated cells lying immediately external to the pericycle and extending from the collet to within about 320 μ of the apex of the root primordia (fig. 7). The frequent periclinal divisions and occasional anticlinal ones contribute new cells to the cortical parenchyma and endodermis, respectively (fig. 7). Occasionally the endodermis becomes more than one cell thick in places.

Small, intercellular spaces originate during the first four days between the endodermis and the cells of the adjoining tissues. Simultaneously Casparian strips are initiated. Although the evidence at hand is insufficient to warrant a positive statement, it seems probable that these thickenings originate on the cell walls adjacent to the intercellular spaces between the endodermis and pericycle and gradually move out the radial walls to about the mid-point.[4] For a few days the Casparian strips become more prominent, but in the second or third week, when the walls of the endodermal cells undergo a chemical change and stain red with safranin, they lose their identity. Collenchymatous thickenings which stain red with safranin occasionally fill the intercellular spaces adjacent to the endodermis. Beginning about the third week and accompanying disintegration of the cortical parenchyma, the endodermis splits and becomes disorganized (fig. 10). By the middle of the third month it appears fragmentary and mostly crushed to extinction in the ridges of bark.

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[3] No endodermis differentiates in either the stem or hypocotyl.

[4] These observations seem to be in accord with the findings of D. S. Van Fleet (20).

PERICYCLE OF ROOT[6]

In the embryo root primordia, the pericycle is differentiated to within 320 μ of the apex as a cylinder of cells bounded on the outside by the endodermis and centrad by much smaller cells of the stele (fig. 7). Anticlinal and periclinal divisions in the pericycle contribute cells respectively to a cylinder of pericycle one cell wide and to two strands of small, dividing cells appearing crescent-shape in cross-section. These strands of pericyclic cells lie on each side of the central axis of the diarch root, with the convex arc adjacent to the cylinder of pericyclic cells. (Cf. pericyclic fiber region (PF) in figs. 7, 9, 10.) During the first four days cells nearest the primary xylem points, in the narrowest parts of the strands, begin vacuolating, and some of their walls begin thickening. By the end of the third week all these closely compacted, dividing cells have enlarged and many have differentiated as fibers with thick, laminated secondary walls (fig. 10). Enlargement and division of the parenchymatous cells within the strands, together with pressures exerted by the increasing amount of secondary xylem and phloem, result in a scattering of the pericyclic fibers within the strands and the further separation of the two fiber groups.

During the latter part of the first week the cells of the pericyclic cylinder enlarge slightly in tangential direction, and concomitantly cells opposite the diarch xylem points in the oldest part of the root begin dividing periclinally. From these two original locations, periclinal cell divisions spread tangentially and acropetally through the pericyclic cylinder. By the end of the third week this pericyclic cambium (phellogen) is complete to a point about 400 μ from the root apex (fig. 10). Both phelloderm and phellem are formed, while the phellogen remains as the middle layer (figs. 10, 11). The thin walls of the loosely compacted phelloderm cells are mostly cellulose, while the tightly compacted cells of the phellem have thick, suberized walls. Toward the end of the first week, secondary root primordia are initiated in the pericycle opposite the points of the diarch xylem. All primordia observed were 3.5 mm. or farther back of the root apex.

PHLOEM

Differentiation is very difficult to observe in the phloem, and therefore exact boundaries of this tissue cannot always be accurately determined. Protophloem and metaphloem are indistinguishable.

In the embryo four strands of small, angular, dividing phloem cells extend through the hypocotyl and to within 380 μ of the root apex. In the hypocotyl they lie opposite the four xylem strands while in the root they lie on each side of the xylem points adjacent to the pericycle (fig. 7). Similar primary phloem groups differentiate out of the procambial strands at the fourth node, about 50 μ from the apex. In the root and hypocotyl during the first week and in the stem ar the time of internode elongation, intercalary cell divisions become less frequent and the cells increase in length and cross-sectional area 2–5 times. The most frequent divisions and the most extreme enlargement of cells occurs in the basal inch of the hypocotyl. Soon after cell enlargement, seive tubes, companion cells, and phloem parenchyma differentiate.

Secondary fascicular phloem begins forming in the roots within the first four days and in the hypocotyl and stem toward the end of the first week. Slow differentiation of secondary interfascicular phloem begins several days following the acropetal differentiation of the interfascicular cambium which is initiated at the base of the hypocotyl during the latter half of the first week. About the second or third week, external to the small portions of secondary vascular cambium, opposite the diarch xylem points in the root, tertiary phloem is initiated. Secondary and tertiary phloem cells are usually larger than those of the primary phloem and lie in radial seriation.

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[6] No pericycle differentiates in either the stem or the hypocotyl.

In the second or third week phloem fibers, resembling those of the cortical parenchyma, become differentiated in the basal inch of the hypocotyl. Differentiation proceeds slowly, acropetally through the hypocotyl and into the stem about the end of the second month. They begin differentiating in the root about the middle of the sixth week.

If the cross-sectional area of the companion cells of a 2½ months-old root is arbitrarily used as one unit, the seive tubes are 2½ units in area, the fibers 5.5 units, and the phloem ray cells 11 units.

Owing to the greater number and size of the parenchyma cells lying between the phloem and the fibers of the cortical parenchyma, phloem fibers may be much more readily distinguished in the lower inch of the hypocotyl than in the upper part. In general, phloem fibers are significantly smaller than fibers of the cortical parenchyma.

VASCULAR CAMBIUM

The fascicular cambium of the embryo extends through the hypocotyl only and appears to have differentiated basipetally. These cambial initials elongate tangentially and soon double or triple in that dimension. In the latter half of the first week, concomitant with the elongation of the first internode of the stem and the origin of the phellogen of the hypocotyl and root, (1) fascicular cambia originate at the hypocotyl end of the root, (2) interfascicular cambia originate in the basal end of the hypocotyl, and (3) fascicular cambia originate in the stem.

Differentiation of the fascicular cambium of the stem proceeds basipetally from the third node (about 20 μ) from the stem apex. Cambial cells initiating xylem vessel elements and tracheids are mostly three times greater in tangential dimension than those initiating xylem parenchyma. Immediately following initiation of fascicular cambia, which occurs quickly, parenchyma cells adjacent to the ends of the fascicular cambia divide periclinally and by the time internode elongation is complete, the tangential extension of the interfascicular cambia is complete. Differentiation proceeds acropetally.

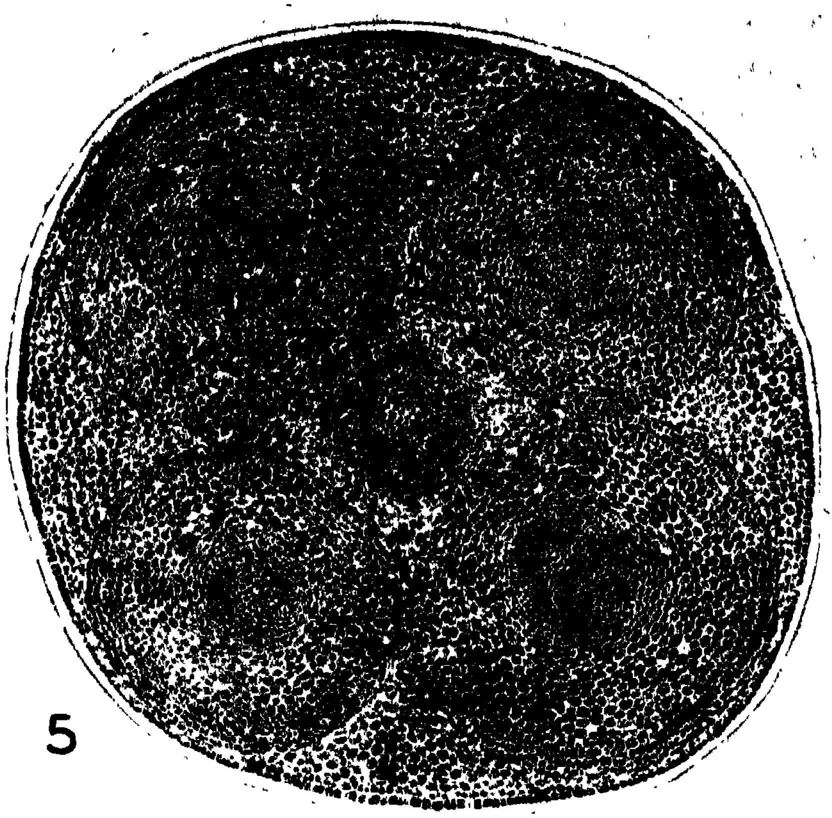
After the initiation of the interfascicular cambia at the ends of the fascicular cambia in the base of the hypocotyl, differentiation proceeds laterally and acropetally. By the second or third week the vascular cambium forms a ring in the basal inch of the hypocotyl and by the sixth week it has become a cylinder extending the length of the organ. The vascular cambium continues to be more active in the basal inch than elsewhere in the hypocotyl.

The interfascicular cambial initials in the stem and the basal inch of the hypocotyl increase in size very rapidly but upon becoming twice or three times as great in tangential dimension as the fascicular cambial cells, they divide anticlinally.

EXPLANATION OF ABBREVIATIONS

Used in Figures 7, 9, 10 and 11

(EP, epidermis; H, hypodermis; CO, cortex; EN, endodermis; PER, pericycle; PC, phellogen originating from the pericycle; PF, pericycle fibers or profiber strands; PH, phloem; CA, vascular cambium; CA_2, secondary vascular cambium; SX, secondary xylem; TX, tertiary xylem; XR, xylem differentiated from phelloderm cells formed by the pericyclic (cork) cambium.)



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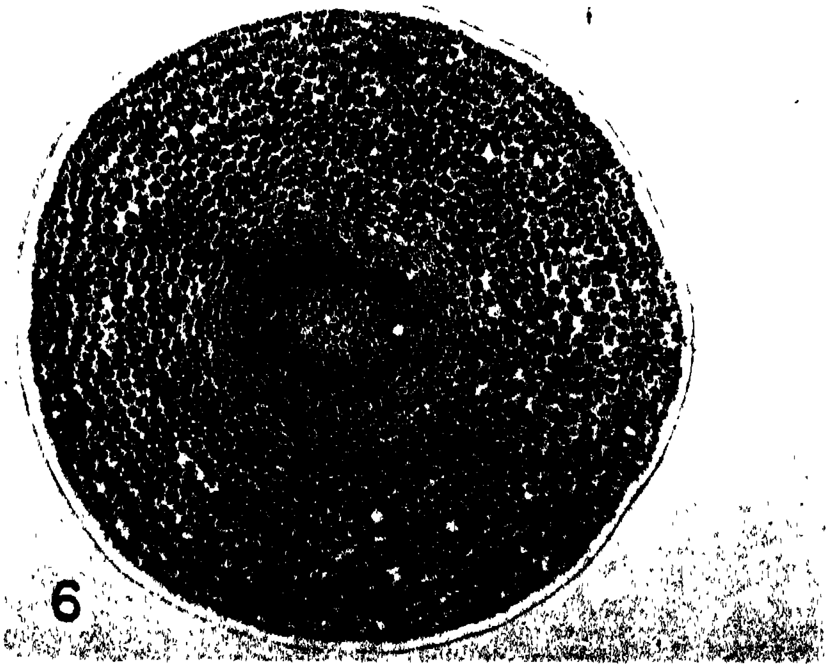

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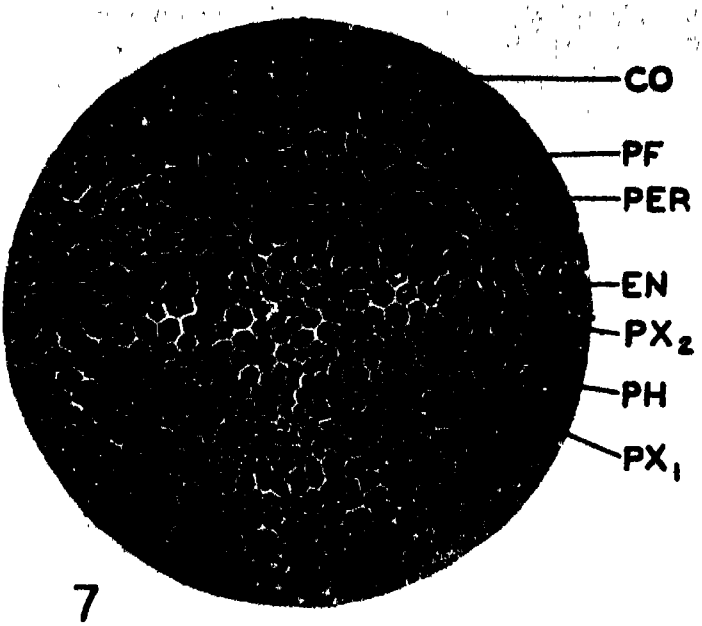
FIG. 5. Cross-section through the basal end of an embryo hypocotyl with cross-sections of a primary and four adventitious roots. × 94

FIG. 6. Cross section through the oldest portion of an embryo primary root. × 45



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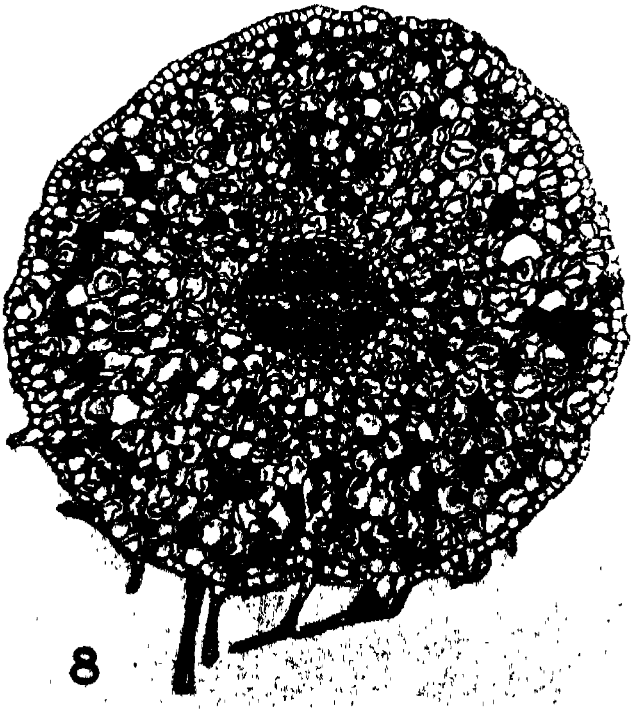

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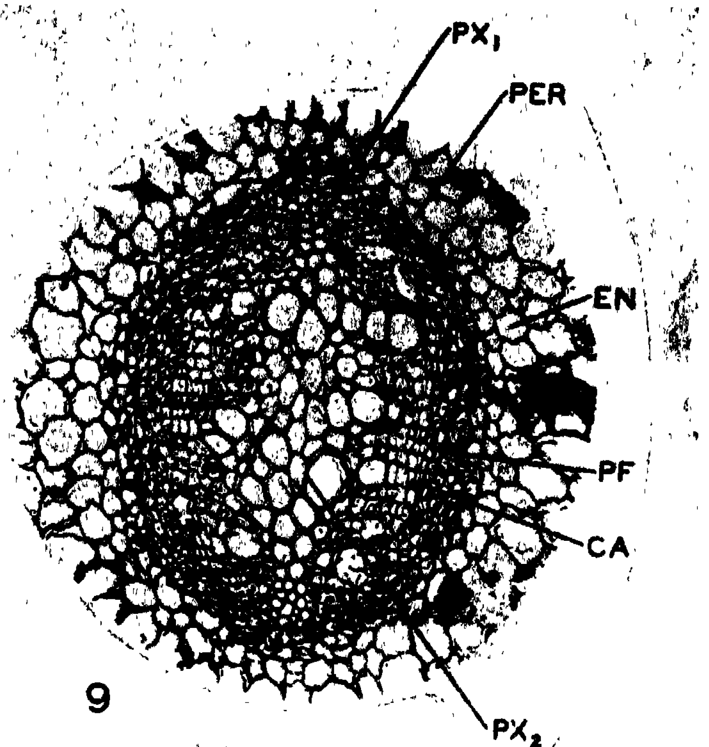
FIG. 7. Cross-section through the central part of the oldest portion of an embryo primary root. × 205

FIG. 8. Cross-section through the oldest portion of a root four days old. × 110



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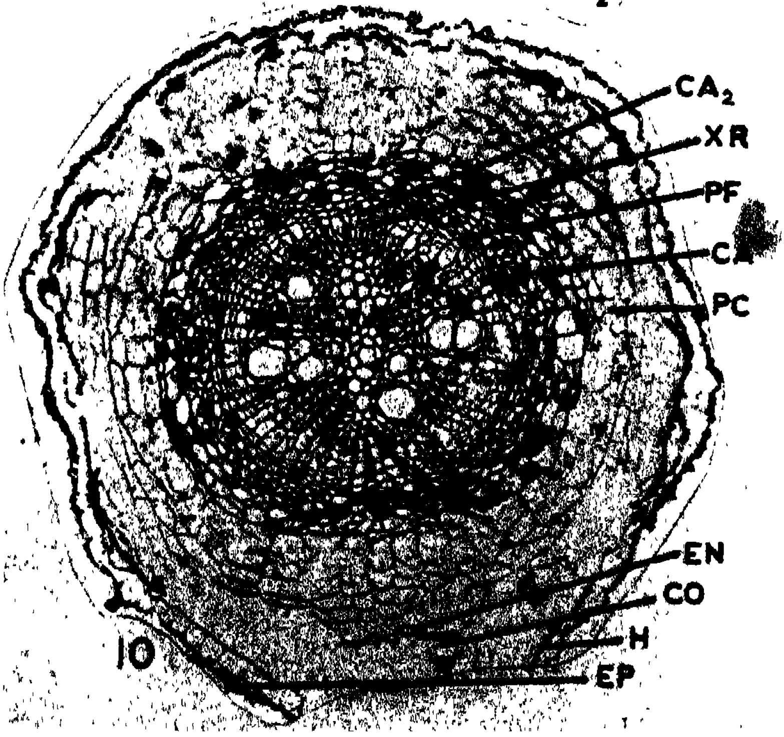

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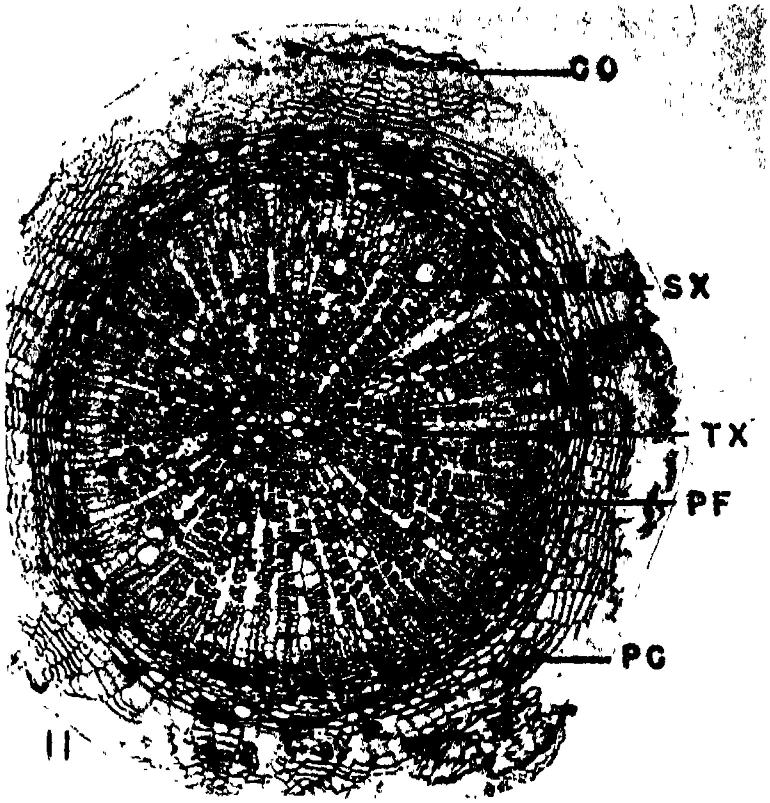
FIG. 9. Cross-section through the central part of the oldest portion of a root seven days old. × 175

FIG. 10. Cross-section through the oldest portion of a root three weeks old. × 121



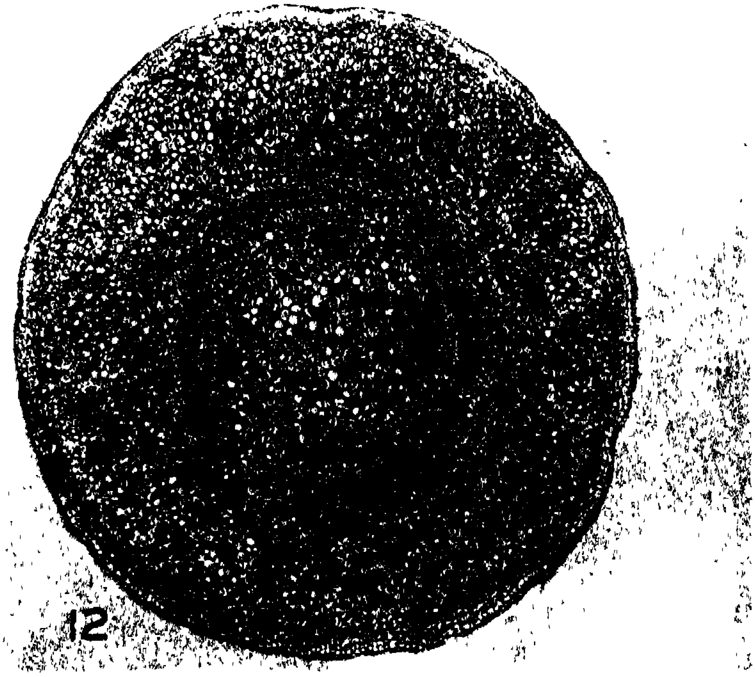
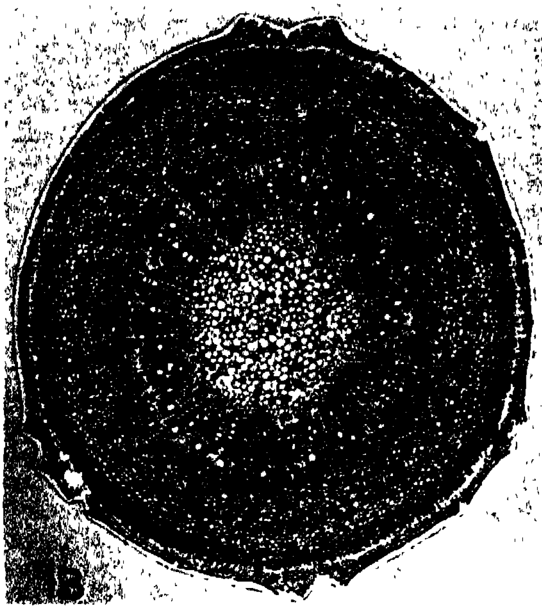


FIG. 11. Cross-section through the oldest portion of a root two and one-half months old. × 48

FIG. 12. Cross-section through the swollen basal end of a hypocotyl seven days old. × 21

The vacuolated initials in the root first appear in four positions along each side of the diarch xylem points but separated from them by xylem parenchyma. The formation of cambial initials proceeds laterally and acropetally until about the end of the first week when the primary vascular cambium is composed of two sheets of cells lying in arcs on each side of the xylem axis (fig. 9). By the end of the third week, and from that time on, they extend to within 1.6 mm. of the root apex. As the xylem increases in bulk, the tangential dimension of the cambial cells doubles or triples. Those initiating xylem or phloem ray parenchyma cells become twice as great in radial and tangential dimensions as other cambial cells. Anticlinal divisions are few.



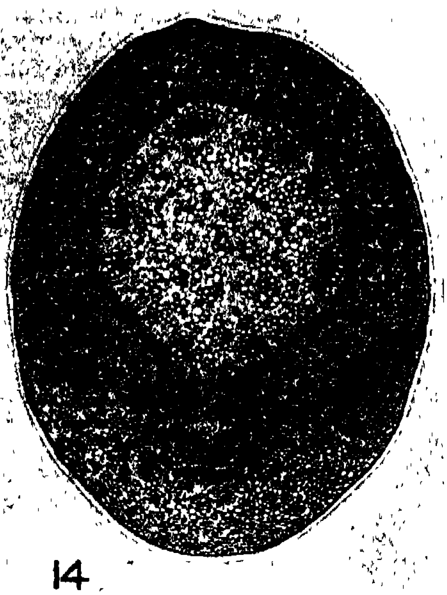


Fig. 13. Cross-section taken immediately above the second node of a stem two and one-half months old. × 23

Fig. 14. Cross-section taken immediately below the seventh node of a stem two and one-half months old. ×17

Most of the secondary tissue which originates from the vascular cambium is xylem (fig. 9), and although the amount of it becomes constantly greater on each side of the central axis, none is formed opposite the xylem points because the vascular cambium has not yet differentiated there (fig. 9). These gaps in the xylem, fan-shaped in cross-section and opposite the diarch xylem points, are in the meantime being filled with phalloderm cells originating from the pericyclic (cork) cambium. The cells are slightly larger than those of the xylem, and many of them are tangentially elongated. Soon after these wedge-shaped groups of phelloderm cells originate, the vascular cambium begins differentiating across them at the hypocotyl end of the root (fig. 10). The differentiation of these secondary portions of the cambial cylinder proceeds so slowly, acropetally, that by the end of the third month they are found only through the upper one-fifth (3 cm.) of the root. The six or seven layers of phelloderm lying centrad of the newly differentiated secondary portions of the vascular cambium become differentiated as xylem (fig. 10).

Sometime after the sixth week, external to the secondary portions of the vascular cambium, phloem becomes differentiated from phelloderm cells, and very soon pericyclic fibers differentiate external to the phloem. In the oldest portion of a 2½ month-old root, the pericyclic fibers form a complete cylinder (fig. 11).

XYLEM

Primary xylem is present in the root but is never found either in the stem or in the hypocotyl, with one minor exception.

A primary diarch xylem is defined in the steles of the embryo root primordia to within 310 μ of the apex, on the basis of cell size and position (figs. 6, 7). The xylem cells nearest the center of the root stop dividing and become greatly enlarged before divisions cease in the cells nearest the pericycle (fig. 7). The first xylem cells to differentiate, therefore, are those larger elements located nearest the center of the root. Within the first day or so, proliferation ceases in the small xylem cells adjacent to the pericycle. Differentiation proceeds from the hypocotyl end of the root to within 1,000 μ of the apex. Lignification and maturation of these cells begins the next day following differentiation and progress rapidly acropetally but rather slowly centripetally. By the end of the fourth day approximately thirty of the elements nearest the pericycle at the hypocotyl end of the root have spiral or annular lignified secondary walls (fig. 8). It is not until about the end of the first week that secondary wall formation and lignification begins in those cells nearest the center of the root. The lignified walls of these cells, which frequently become 3 μ thick, are reticulate or occasionally pitted.

Simultaneous with the formation of the two arcs of vascular cambium, xylem fibers become differentiated from primary cells on opposite sides of the diarch xylem axis. The xylem fibers are similar to the pericyclic and phloem fibers, except that on the average they are two or three times larger in cross-sectional area. Their secondary walls are slightly lignified, often becoming 3 μ thick but they frequently contain cytoplasm and nuclei. Differentiation of fibers from primary and then from secondary xylem parenchyma proceeds rapidly, centrifugally, on both sides of the lignified xylem axis (figs. 8, 9, 10, 11). Differentiation and lignification of additional vessel elements scattered among the fibers occur only occasionally, but those formed are usually extremely large.

When the secondary portions of the vascular cambium differentiate across the wedges of secondary tissue opposite the xylem points (fig. 10), the cells lying centrad of them differentiate as xylem fibers, parenchyma, and lignified elements. Cells initiated centripetally by the secondary portions of cambium become differentiated as tertiary xylem (fig. 11).

Uniseriate or biseriate rays of xylem parenchyma begin differentiating during the fifth or sixth week. These large, thin-walled cells are sometimes crushed by the enlarging elements adjacent to them. In the oldest part of a root 2½ months old, lignified elements, very few of which are located in tertiary tissue, comprise about 10 per cent of the xylem bulk. Xylem parenchyma, most of which lies in xylem rays and close to the cambium, makes up about 20 per cent of the xylem. The remaining 70 per cent consists of fibers (fig. 11). The largest cells of each type are those most recently initiated by the cambium. This is partly due to the gradual increase in size of the vascular cambium initials.

The secondary xylem of the embryo hypocotyl lies in four equally spaced strands which are continuations of the cotyledonary bundles (fig. 12). Each xylem strand contains about five radial rows of enlarged cells which later mature as vessels. Each of the rows is separated by one or more rows of xylem parenchyma. Since there are five vessel initials per row in the basal end of the hypocotyl and six at the top end, it may be inferred that differentiation of the vascular cambium and its secondary xylem proceeded basipetally. Maturation, indicated by lignification of secondary thickenings and disintegration of cell contents, follows quickly, centrifugally during the first four days. On the third or fourth day the maximum number of vessels per row is reached, there being about eight per row in the basal inch and six per row in the rest of the hypocotyl. In the first lignified vessels the thickenings are annular, and in successively younger elements, stretched spirals, spirals, and tight spirals were observed. Some of the cells of the xylem parenchyma lying between the rows of vessels enlarge greatly and become differentiated as uniseriate, or occasionally biseriate, xylem rays which are perpetuated by divisions of certain cambial cells. Most of the cells differentiate as xylem fibers possessing slightly lignified, cellulose, secondary walls which frequently become 3 μ thick. At this same time, several very small cells with annular, partly lignified thickenings become differentiated from the primary pith parenchyma at the secondary xylem points

Between the fourth and seventh days xylem cells are initiated by the interfascicular cambium in the basal inch of the hypocotyl and rapidly enlarge until they are nearly comparable in cross-sectional area to the largest vessels. Additional cells are formed as the interfascicular cambium differentiates laterally and acropetally. The first five layers of cells produced before the end of the third week remain parenchymatous. Many of the cells initiated between the third and sixth weeks in the basal end of the hypocotyl differentiate as fibers. Among these are scattered a few vessels whose secondary walls become thick and lignified. Sometimes after the sixth week rays of large parenchyma cells differentiate in the interfascicular xylem.

The secondary xylem of the stem originates at the third node, about 20 μ from the stem apex with the differentiation of one small strand of cells representing the downward extension of the central vascular bundle of the leaf primordium attached at that node. At the time of internode elongation twelve leaf traces are differentiated (fig. 14). In each trace there are about five uniseriate plates of xylem parenchyma alternating with four uniseriate plates of vessels. Vessels continue differentiating until about the sixth week, when the maximum number (five to nine) per radial row has been reached. In the second or third week xylem fibers begin differentiating from newly formed secondary xylem parenchyma, and by the middle of the third month the secondary cellulose walls are 1 μ thick.

Vessel differentiation in the leaf traces is basipetal through the stem, as evidenced by the decrease in vessel number, secondary wall thickness, and secondary wall lignification. Initiation and lignification of vessels occur first in the larger central trace of the leaf, and later in the two lateral traces.

During the second week the interfascicular cambia of the stem begin differentiating acropetally and tangentially from the ends of the fascicular cambia. The first few layers of xylem cells, those lying farthest centrad remain parenchymatous, but most of those cells originating from the interfascicular cambia after the third week differentiate as fibers. Occasional vessels differentiate among the fibers of both the fascicular and interfascicular xylem (fig. 13). Beginning about the sixth week uniseriate rays composed of large parenchymatous cells differentiate throughout the xylem. Occasionally the walls of these cells become slightly thickened.

PITH

Pith is the first tissue of the root to differentiate. Its closely compacted, angular cells extend to within 300 μ of the root apex and form a continuation of the pith of the hypocotyl. The large cells usually remain parenchymatous but occasionally the walls become slightly thickened.

In the embryo hypocotyl the cells are loosely compacted, dense with cytoplasm, and contain much starch, most of which disappears during the third week. Anticlinal and periclinal divisions occur frequently only in the lower end of the hypocotyl. Divisions cease during the first four days but are reinitiated in the fourth or fifth week. The cells begin enlarging soon after their formation, and by the third week those in the base of the hypocotyl have increased in cross-sectional area more than seven times, those in the upper parts more than two times. Cell elongation occurs concomitantly and is approximately equal in the cells throughout the organ. On about the seventh day a cavity formed by the tearing of cells in the center of the pith originates in the base of the hypocotyl, and by the third week it extends throughout the organ.

Pith becomes differentiated in the stem at about the fourth node, 60 μ from the apex. The cells are closely compacted and contain no starch. Cell divisions occurring in all planes cease at about the time of internode elongation. The cells gradually become rounded as they increase greatly in size.

DRUSES AND LATICIFEROUS CELLS

Large, spherical aggregates of crystals (druses), presumably of calcium oxalate, and appearing yellow in prepared sections, were observed filling isolated cells in many tissues of the plant. They first appear in the cortical parenchyma of the root on about the seventh day; in the tissue lying centrad of the pericyclic (cork) cambium in the second or third week; and in the phloem, especially in the phloem rays, sometime after the sixth week. In the hypocotyl they first appear in the cortical parenchyma and pith between the fourth and seventh days; in the phloem and hypodermis between the first and third weeks; and in the xylem sometime after the sixth week. In the stem they first occur in the hypodermis, cortical parenchyma, phloem, and pith in the second or third week.

Laticiferous cells occur singly, or form short crooked tubes in many tissues of the plant. The contents of these cells stain red with safranin. In the root, laticiferous cells differentiate in the xylem, phloem, and tissue centrad of the pericyclic (cork) cambium, during the second or third week In the hypocotyl they differentiate in the cortical parenchyma of the embryo; in the phloem during the fifth or sixth day; and in the xylem between the first and third weeks. Both druses and laticiferous cells are more abundant in the basal inch of the hypocotyl than in the upper parts of the organ. In the stem they differentiate among the cells of the meristem in the embryo stage. After tissue differentiation, they are found in the cortical parenchyma. Latex frequently fills the lignified vessels in the stem.

TERMINOLOGY

In this paper, a cell or tissue is considered *differentiated* from a group of cells when it can be distinguished from them on the basis of differences in cell size, shape, contents, rate of cell division, or differences in the cell wall. It has been assumed that the cell or tissue continues differentiating as long as visible[6] changes occur in it.

The term *mature* has been applied to cells which are incapable of further differentiation, that is, dead cells. The writer is aware that cells may become "physiologically mature" long before death but—since it is impossible to determine whether the processes in a cell will undergo considerable change later in life or remain more or less constant—it is impossible to determine when a cell is "physiologically mature."

In recording the observations on xylem, it will be noted that use of the terms *proto-* and *metaxylem* has been avoided. So many misconceptions regarding these terms are at large in the literature that they no longer convey the same meaning to all plant anatomists. It would seem, therefore, that these concepts are in urgent need of re-examination and revision in the light of recent facts.

The terms were proposed by Russow (13) in 1872. As defined by him, protoxylem refers to the first xylem elements to *differentiate*. He states not only that these elements are primary in origin, but that they are the first to become thick walled and hence to mature. He realized, however, that the pattern of the secondary wall is directly related to the degree and speed of cell elongation at the time of secondary wall formation.

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[6] It is understood that physiological differentiation precedes visible differentiation and that it may continue afterward.

DeBary (2) apparently retained the term as defined by Russow but imposed one additional limitation by stating that protoxylem consists of tracheae with spiral or annular thickenings.

According to Coulter, Barnes, and Cowles (1), "The first xylem elements to appear (in the stem) are small in caliber, and of the spiral kind, a kind especially adapted to a region of rapid elongation. These groups of spiral vessels are called the *protoxylem*, and the later vascular elements form the *metaxylem*."

In Eames and MacDaniels (3), "The first cells of the phloem to mature are known as the *protophloem*, those of the xylem, the *protoxylem*." The cells of the protoxylem are further characterized as being primary in origin, narrow and slender, and possessing annular, spiral, or perhaps scalariform secondary walls.

Hayward (6) states that "The primary xylem is further divided into the *protoxylem*, which is the first to differentiate and mature at a given locus, and the *metaxylem*, which usually matures later." Elsewhere he defines protoxylem as "the first elements of primary xylem to be differentiated, characterized by annular, spiral, or reticulate secondary walls."

Priestly and Scott (11) have showed that the xylem of *Helianthus annuus* stem is all secondary in origin. The first xylem elements to differentiate are also the first to mature and possess annular or spiral secondary walls. Those elements differentiating and maturing later are characterized by scalariform, reticulate, and pitted secondary cell walls. In the roots of *Helianthus*, the first xylem formed is primary in origin. These workers offer the suggestion that "It would seem far better to use the terms 'primary' and 'secondary' with their usual implications and to recognize them in the shoot, . . . the protoxylem is usually secondary, being derived from the inner members of the radial series of cells cut off from the cambium." Since protoxylem and metaxylem have in the past connoted primary origin to most of us, it would seem that although this suggested usage of the terms is fundamentally sound, general acceptance and accomplishment of such a change would be a practical impossibility and would only result in further confusion in the literature.

Stover (18) has called attention to the absence of xylem elements with annular or spiral secondary walls in the slow-growing rhizomes of *Agropyron repens*, *Spartina michauxiana*, and *Calamovilfa longifolia*. In the same paper he also reports that in the vascular bundles of rapidly growing young plants of *Zea mays*, all of the xylem vessels possess annular or spiral secondary walls and that these vessels are extremely large. All of the xylem in the species with which Stover worked was primary in origin.

In *Jatropha cordata*, it has been noted that the first xylem cells to differentiate in the stem are also the first to mature. All of the xylem is secondary in origin. In the hypocotyl, the first xylem cells to differentiate are the first to mature. Most of the xylem in the hypocotyl is secondary although a few primary elements may differentiate and mature after a considerable quantity of secondary xylem has matured. The first xylem cells to differentiate in the roots are located in the center of the root and are primary in origin. The last cells of the primary xylem to differentiate (lying nearest the pericycle) are the first cells of the primary xylem to mature. Secondary xylem forms after all of the primary xylem has differentiated and after much of it has matured. The cells of the xylem with annular and spirally thickened secondary walls were always found to be the first cells to mature although these cells were secondary in origin in the stem and hypocotyl and primary in origin in the root.

The data cited above are conclusive evidence that in the differentiation of xylem cells, the size, location, time of enlargement, time of secondary wall lignification, time of differentiation, and the pattern of the secondary wall do not always bear a specific or constant relationship to the kind of origin, whether primary or secondary. In view of the existing confusion, it seems that the most practical solution of the problem is to discard entirely the terms proto- and metaxylem in

TABLE I

DIRECTION, PLACE, AND TIME OF TISSUE DIFFERENTIATION IN THE ROOT, HYPOCOTYL, AND STEM

Tissue	Organ	Direction of Differentiation	Place and/or Time of Differentiation
Epidermis	Root	A	370 μ from root apex; prior to planting
	Hypo.	?	Prior to planting
	Stem	A	10 μ from stem apex, at base of apical meristem; within first 4 days
Hypodermis	Root	A	370 μ from root apex; within first 4 days
	Hypo.	?	Prior to planting
	Stem	A	10 μ from stem apex, at base of apical meristem; within first 4 days
Hypodermal cambium.	Root	N	None
	Hypo.	A	Base of hypocotyl; between fourth and seventh days
	Stem	A	Base of stem; between first and third weeks
Cortical parenchyma.	Root	A	320 μ from root apex; prior to planting
	Hypo.	?	Prior to planting
	Stem	A	10 μ from stem apex, at base of apical meristem; within first 4 days
Endodermis	Root	A	320 μ from root apex; prior to planting
	Hypo.	N	None
	Stem	N	None
Pericycle	Root	A	320 μ from root apex; prior to planting
	Hypo.	N	None
	Stem	N	None
Pericyclic cambium	Root	A	400 μ from root apex; between fourth and seventh days
	Hypo.	N	None
	Stem	N	None
Primary phloem	Root	A	380 μ from root apex; prior to planting
	Hypo.	?	Prior to planting
	Stem	B (?)	Fourth node below stem apex; after fourth day
Vascular cambium	Root (pri)	A	1600 μ from root apex; within first four days
	Root (sec)	A	At collet; between first and third weeks
	Hypo. (fas)	B (?)	Prior to planting
	Hypo. (int)	A	Base of hypocotyl; between fourth and seventh days
	Stem (fas)	B	20 μ from stem apex, at third node from stem apex; after fourth day
	Stem (int)	A	At internode elongation; after fourth day
Primary xylem	Root	A	310 μ from root apex; prior to planting
	Hypo.	A	Within first 4 days
	Stem	N	None
Pith	Root	A	300 μ from root apex; prior to planting
	Hypo.	?	?
	Stem	A	60 μ from stem apex, at fourth node from stem apex; within first 4 days

A, acropetal; B, basipetal; N, none differentiated; pri, primary tissue; sec., secondary tissue; fas, fascicular; int, interfascicular.

favor of meaningful descriptive phrases such as "the first xylem cells to differentiate," "the first xylem cells to mature," or "the xylem elements with spiral, annular, reticulate, or scalariform thickenings," whichever is applicable to the case at hand. It will, of course, be necessary to make clear whether the cells are primary or secondary in origin.

SUMMARY

1. The time and place of origin of the various tissues of the root, hypocotyl, and stem are summarized in Table I. It is apparent that a high degree of tissue differentiation has already taken place in the root primordia and hypocotyl of the embryo by the time of seed maturity, while very little has occurred in the epicotyl.
2. The relative quantities of the various tissues present at different times during the enlargement of the root, hypocotyl, and stem are summarized in figures 1–4.
3. The order of tissue differentiation in the root is (1) pith, (2) primary xylem nearest the center of the root, (3) pericycle, endodermis, and the inner boundary of the cortical parenchyma, (4) hypodermis and epidermis, (5) primary phloem, (6) primary xylem nearest the pericycle, (7) the primary vascular cambium and secondary xylem and phloem, (8) the pericyclic (cork) cambium, and (9) the portions of secondary cambium and tertiary xylem and phloem.

   The order of tissue differentiation in the hypocotyl is (1) epidermis, hypodermis, cortical parenchyma, primary phloem (both fascicular and interfascicular), primary fascicular cambium, and pith, (2) secondary fascicular xylem, (3) secondary fascicular phloem and primary xylem, (4) primary interfascicular cambium and secondary interfascicular xylem and phloem.

   The order of tissue differentiation in the stem is (1) epidermis, hypodermis, and cortical parenchyma, (2) pith, (3) primary fascicular cambium and secondary xylem, (4) primary phloem, (5) secondary fascicular phloem, (6) primary interfascicular cambium and secondary interfascicular xylem and phloem.
4. The hypocotyl cannot be considered a portion of the stem occupied by the transition region but should be thought of as an organ of the plant possessing a developmental anatomy peculiar to it alone.
5. Elongation of the hypocotyl is due primarily to cell elongation rather than cell division.
6. The phenomena accounting for the extreme enlargement at the base of the hypocotyl are, (a) very little cell elongation accompanies cell enlargement in the base of the hypocotyl while in the upper parts, cell elongation is extreme and accounts for most of cell enlargement, (b) the interfascicular cambium is initiated in the base of the hypocotyl, (c) cambial initials become larger in the base of the hypocotyl and finally divide anticlinally, increasing the total number of cambial cells, (d) reinitiation of intercalary cell divisions throughout the cortex of the hypocotyl commences in the basal end.
7. In the root, a diarch primary xylem is differentiated. The cells nearest the pith differentiate first while the cells nearest the pericycle mature first. In the hypocotyl, an extremely small amount of primary xylem is differentiated after some secondary xylem has formed. No primary xylem is differentiated in the stem.
8. Fibers with thick, cellulose walls comprise more than half of the xylem throughout the mature plant.
9. In the root, during the second or third week, secondary cambia differentiate

across the secondary tissue opposite the xylem points and from it arise tertiary xylem and phloem.

10. Secondary root primordia become initiated in the pericycle opposite the points of the diarch xylem toward the end of the first week.

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OHIO SHALE CONODONTS

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Although conodonts are numerous in the Ohio shale, they have received very little attention. To my knowledge, Cooper's paper (1931a), in which seven species are described from the top of the shale just northeast of Columbus, is the only publication on the subject. The present study encompasses a large variety of species and is the forerunner of a comprehensive study of the conodont fauna.

The material for this paper was collected from the lower portion of the Ohio shale where it is exposed along a few small tributary streams of the Olentangy River about two miles northwest of Worthington, in central Franklin County. Thirty-seven previously described species and eighteen genera are recognized. Twelve forms are unassigned because of doubtful relationships. Among these may be several new species and at least one new genus It is hoped that these doubtful forms can be described when additional material is collected and studied.

The species described in this paper are listed as follows:

Ancyrognathus irregularis Branson and Mehl

Bryantodus commutatus Huddle
Bryantodus concavus Huddle
Bryantodus germanus Holmes
Bryantodus inequalis Holmes
Bryantodus nitidus Ulrich and Bassler
Bryantodus serrulus Huddle
Bryantodus subcarinatus Huddle
Bryantodus subequalis Cooper
Bryantodus subplanus Huddle

Euprioniodina prona Huddle

Hibbardella angulata (Hinde)
Hindeodella aculeata Huddle
Hindeodella alternata Ulrich and Bassler
Hindeodella germana Holmes
Hindeodella subtilis Ulrich and Bassler
Hindeodella sp. 1
Hindeodella sp. 2

Hindeodelloides bicristatus Huddle

Ligonodina sp. 1
Ligonodina sp. 2
Ligonodina sp. 3

Lonchodina multidens Hibbard
Lonchodina perarcuata Ulrich and Bassler
Lonchodina perlonga Ulrich and Bassler

Metaprioniodus biangulatus Huddle

Ozarkodina delicatula (Stauffer and Plummer)

Palmatodella delicatula Ulrich and Bassler
Palmatodella ? sp.

Palmatolepis glabra Ulrich and Bassler
Palmatolepis quadrantinodosa Branson and Mehl
Palmatolepis regularis Cooper
Palmatolepis subperlobata Branson and Mehl

Polygnathus nodocostata Branson and Mehl
Polygnathus pennatuloidea Holmes
Polygnathus sublatus Ulrich and Bassler
Polygnathus sp.

Prioniodina separans Holmes

Prioniodus alatoides Holmes
Prioniodus alatoideus Cooper
Prioniodus alatus Hinde
Prioniodus cultratus Ulrich and Bassler

Spathognathodus subrectus (Holmes)

Subbryantodus radians Branson and Mehl
Subbryantodus sp.

Synprioniodina sp.

Distacods, 3 sp.

Dermal plates, 2 sp.

No additional evidence is furnished by the present conodont collection to aid in the solution of the general problem of the stratigraphic position of the Ohio shale. It is expected, however, that future studies will reveal data of value in determining the age relationships of the formation.

The conodonts occur most commonly in very thin bone beds in the shale, with only occasional specimens scattered between the beds. Some of these bone beds are located at the contacts between the black shale and interbedded layers of gray shale. Others may be found as very thin layers along bedding planes in black shale of uniform lithology. In most places the conodonts are rather evenly distributed laterally, but in one place at least they are concentrated in small discontinuous patches which consist largely of conodont fragments. This latter occurrence suggests that they were brought together by small eddies or currents in the water and that they were moved about considerably as they were being deposited, thus resulting in their fragmental condition.

The state of preservation of the conodonts at the different exposures varies in a marked degree In some places the fossils are largely broken, but the fragments are excellently preserved. In other layers the conodonts have been dissolved away by the sulfuric acid produced by the weathering of pyrite and marcasite in the shale outcrops and have left clearly defined impressions or molds which are usually sufficiently complete to permit identification

The conodonts are quite variable in color, some being white, some amber-colored and transluscent, and others are colorless and so transparent that the shale on which they lie may be seen through them. Many of the specimens examined have a high luster. In general, the fossils of any one bed are similar in color regardless of the species

Associated with the conodonts are small dermal plates, minute black spines, small carbonaceous fragments of wood, and a great abundance of plant spore cases which are in some instances so numerous that the surfaces of the shale are almost completely covered with them. In two of the bone beds which were studied a fine network of minute cylindrical tubes was observed. These are filled mostly with pyrite and marcasite crystals, but in places they are hollow. Their identity is unknown.

For the most part the conodonts described in this paper had to be studied in place on the slightly weathered surfaces of the thin layers of shale, because when the rock was broken down the conodonts fell apart along minute fractures. Some fossil material was separated successfully from the shale by boiling in a solution of sodium hydroxide, and the conodonts were recovered by sifting and by using liquid separates. Material thus separated from the shale consisted largely of fragments, but some identifiable specimens of the simple cone type as well as many minute specimens of the platform type were recovered. These will be studied at a later time.

The total number of fossils preserved sufficiently well for study was about 450. This is a rather small number considering that at least thirty-seven species are represented. Branson and Mehl have also noted a proportionately large number of species relative to the specimens examined in their collections from the Harding sandstone of Colorado (1933a, p. 22), and from the Grassy Creek shale of Missouri (1933b, p. 183).

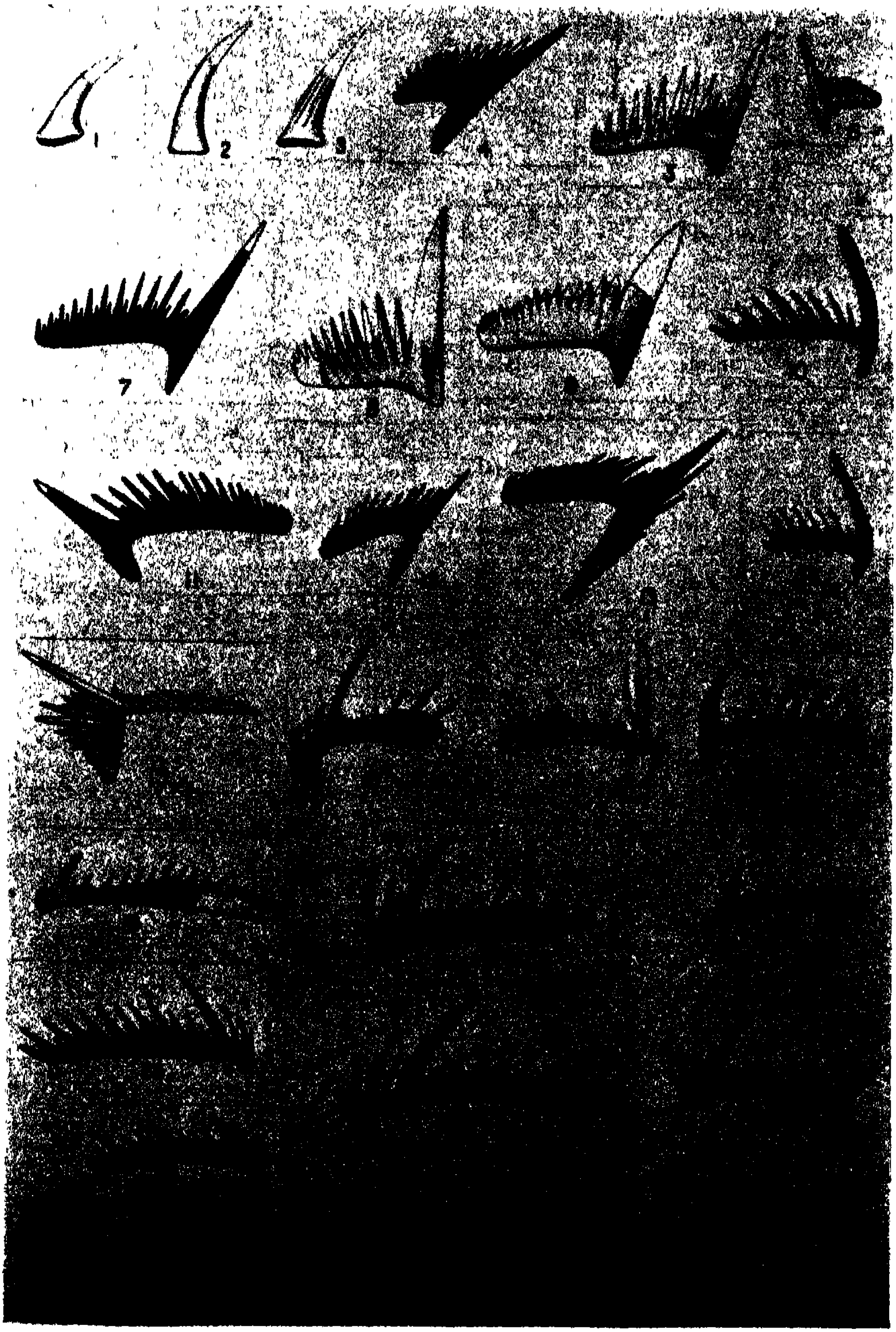
Acknowledgment is made of the assistance of Dr. Grace A. Stewart of the Department of Geology, Ohio State University, who directed the paleontological research.

EXPLANATION OF PLATE I

All specimens are from the lower portion of the Ohio shale, upper Devonian, central Ohio. Magnification as noted.

Figs. 1-3, Distacodidae. Figured specimens: ×50 (p. 23). **4, 6,** *Prioniodus alatoideus* Cooper. Hypotypes: 4, an impression, ×30; 6, × 25 (p. 23). **5, 7,** *Prioniodus alatoides* Holmes. Hypotypes: 7, an impression. ×25 (p. 23). **8,** *Prioniodus cultratus* Ulrich and Bassler. Hypotype: ×25 (p. 23). **9,** *Prioniodus alatus* Hinde. Hypotype: ×20 (p. 23). **10,** *Ligonodina* sp. 1. Figured specimen: an impression. ×12 (p. 23). **11, 12,** *Euprioniodina prona* Huddle. Hypotypes: impressions. ×25 (p. 23). **13,** *Synprioniodina* sp. Figured specimen: an impression. ×20 (p. 23). **14,** *Ligonodina* sp. 2. Figured specimen: an impression. ×10 (p. 23). **15,** *Palmatodella delicatula* Ulrich and Bassler. Hypotype: ×20 (p. 23). **16, 17,** *Hindeodelloides bicristatus* Huddle. Hypotypes: 16, an impression, ×20; 17, ×25 (p. 23). **18,** *Ligonodina* sp. 3. Figured specimen: an impression. ×12 (p. 23). **19, 21,** *Hindeodella aculeata* Huddle. Hypotypes: ×12 (p. 23). **20,** *Hindeodella* sp. 2. Figured specimen: an impression. ×25 (p. 23). **22,** *Hindeodella germana* Holmes. Hypotype: an impression. ×15 (p. 23). **23,** *Hindeodella alternata* Ulrich and Bassler. Hypotype: an impression. ×24 (p. 23). **24,** *Hindeodella* sp. 1. Figured specimen: an impression. ×14 (p. 23). **25,** *Hindeodella subtilis* Ulrich and Bassler. Hypotype: ×20 (p. 23). **26,** *Palmatodella ?* sp. Figured specimen: an impression. ×20 (p. 23). **27,** *Prioniodina separans* Holmes. Hypotype: ×12 (p. 23).

PLATE I



SYSTEMATIC DESCRIPTIONS

Family **Distacodidae** (Ulrich and Bassler, 1926)

The specimens illustrated on Plate I, figures 1–3, represent a small group of distacods recovered from conodont bone bed material by boiling, washing, and screening through the 100-mesh sieve They are somewhat smaller than many of the distacods described in the literature, but they compare favorably in size with several specimens from Pander's conodont material which was available for comparison. An opaque white appearance is developed more or less completely in these tiny cones, a characteristic which they share with the blade or platform type conodonts recovered with them in the screenings. This opacity conceals the growth axes The upper parts of the cones have been broken away, but otherwise the luster, striae, and thin edges of the basal cavities are well preserved. Pending the collection and study of additional material no specific nor generic assignments can be made with any assurance at this time.

The illustration on Plate I, figure 1, represents a minute, simple cone having a base which is extended and flared both anteriorly and posteriorly. The basal cavity is moderately large. The cusp is thin, long, curved moderately, slightly compressed laterally, smooth, with a faint keel developed on the anterior edge. (Figured specimen, Ohio State University Geological Museum, no. 18367c.)

Figure 2 on Plate I illustrates a simple cone with a small oval base which is very slightly expanded and has a rather shallow cavity. The cusp is oval in cross-section, smooth, and slightly curved, forming a high angle with the plane of the base. (Figured specimen, Ohio State University Geological Museum, no. 18367a.)

The specimen illustrated on Plate I, figure 3, is a simple cusp with the base slightly but sharply expanded with a broad, shallow basal cavity, and a thin-lipped basal edge. The cusp is laterally compressed, marked with longitudinal striae and a small sharp keel on the anterior edge. It is slightly inclined and curved and thus forms a high angle with the plane of the base. (Figured specimen, Ohio State University Geological Museum, no. 18367b.)

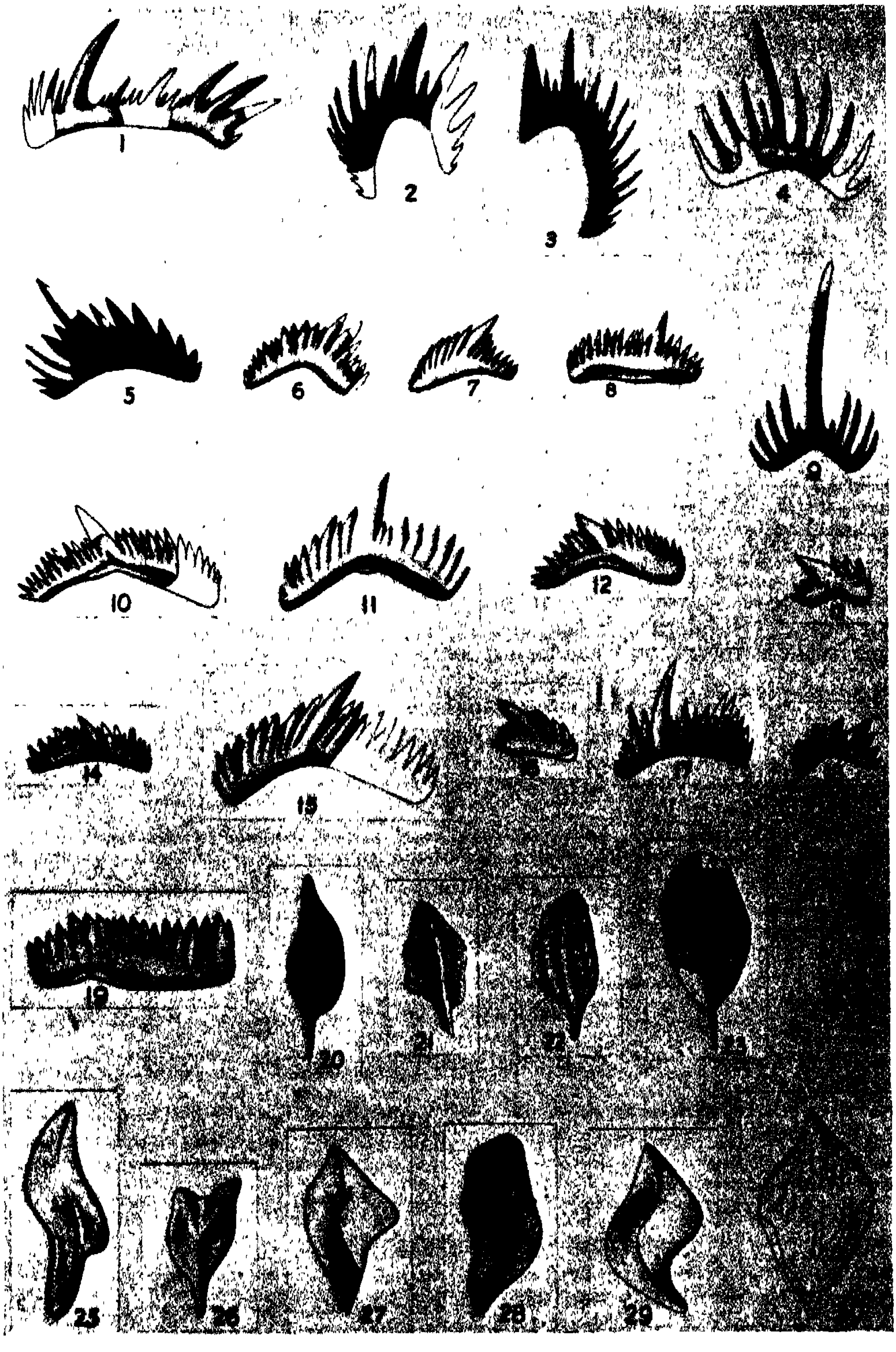
How should the presence of these simple cones in Devonian strata be interpreted? Branson and Mehl (1933b, p. 210) on the basis of their extensive conodont collections, believe that the distacods died out in the Silurian, and Ellison in his recent table showing the stratigraphic ranges of conodonts (1946, p. 94, fig. 1)

EXPLANATION OF PLATE II

All specimens are from the lower portion of the Ohio shale, upper Devonian, central Ohio. Magnification as noted.

Fig. 1, *Metaprioniodus biangulatus* Huddle. Hypotype. ×30 (p. 25). **2**, *Lonchodina perarcuata* Ulrich and Bassler. Hypotype: an impression. ×15 (p. 25). **3**, *Lonchodina multidens* Hibbard. Hypotype: an impression. ×20 (p. 25). **4**, *Lonchodina perlonga* Ulrich and Bassler. Hypotype. ×25 (p. 25). **5**, *Bryantodus concavus* Huddle. Hypotype: an impression. ×30 (p. 25). **6**, *Bryanthodus commutatus* Huddle. Hypotype: ×24 (p. 25). **7, 12**, *Ozarkodina delicatula* (Stauffer and Plummer). Hypotypes: ×30 (p. 25). **8**, *Bryantodus germanus* Holmes. Hypotype: ×24 (p. 25). **9**, *Hibbardella angulata* (Hinde). Hypotype: an impression. ×12 (p. 25). **10**, *Bryantodus inequalis* Holmes. Hypotype: ×18 (p. 25). **11**, *Bryantodus nitidus* Ulrich and Bassler. Hypotype: a restoration based on mold. ×20 (p. 25). **13**, *Subbryantodus radians* Branson and Mehl. Hypotype: ×30 (p. 25). **14**, *Bryantodus serrulus* Huddle. Hypotype: ×25 (p. 25). **15**, *Bryantodus subcarinatus* Huddle. Hypotype: ×20 (p. 25). **16**, *Bryantodus subequalis* Cooper. Hypotype: ×30 (p. 25). **17**, *Bryantodus subplanus* Huddle. Hypotype: ×25 (p. 25). **18**, *Subbryantodus* sp. Figured specimen: ×24 (p. 25). **19**, *Spathognathodus subrectus* (Holmes). Hypotype: ×20 (p. 25). **20**, *Polygnathus* sp. Figured specimen: ×35 (p. 25). **21**, *Polygnathus pennatuloides* Holmes. Hypotype: ×20 (p. 25). **22**, *Polygnathus nodocostata* Branson and Mehl. Hypotype: ×12 (p. 25). **23**, *Polygnathus sublatus* Ulrich and Bassler. Hypotype: ×15 (p. 25). **24, 30**, Dermal plates. Figured specimens: 24, ×12; 30, ×8 (p. 25). **25**, *Palmatolepis glabra* Ulrich and Bassler. Hypotype: ×20 (p. 25). **26**, *Ancyrognathus irregularis* Branson and Mehl. Hypotype: ×12 (p. 25). **27**, *Palmatolepis subperlobata* Branson and Mehl. Hypotype: ×20 (p. 25). **28**, *Palmatolepis quadrantinodosa* Branson and Mehl. Hypotype: ×20 (p. 25). **29**, *Palmatolepis regularis* Cooper. Hypotype: ×12 (p. 25).

PLATE II



emphasizes their Silurian extinction. These authors state that the numerous references to post-Silurian distacods in the literature are the result of failure to recognize that the cones are the broken-off cusps of Devonian or younger blade and bar types of conodonts or are foreign elements in stratigraphic admixtures. They have discussed many of these mixed faunas in considerable detail (Branson and Mehl, 1940; Ellison, 1946, pp. 100–102).

There is no evidence to suggest that the Ohio shale distacods are an admixture from earlier stratigraphic horizons. The specimens were collected from strata well above the basal contact of the formation, and there is no indication of any intraformational breaks The distacods have essentially the same color and luster as the typical Devonian genera *Palmatolepis* and *Hindeodella*. The presence of distinct basal cavities and smooth, perfectly defined, unbroken basal margins unquestionably relates them to the family Distacodidae and eliminates *Lonchodina* and *Euprioniodina* assignments such as Branson and Mehl have made for some of their Grassy Creek cone-shaped conodonts (1933b, pp. 210, 211, pl. 15, figs. 15, 21).

The problem resolves itself into a study of three alternatives· 1, the recognition of a stratigraphic admixture; 2, an extension of the range of the distacods beyond the Silurian; 3, separation of these Devonian forms from the family Distacodidae on some basis, however slight, frankly for utilitarian purposes. This last alternative is comparable to the problem of variability of species as commented upon by P. E Raymond (1941, p. 99), who points out that specimens from zones of different ages are split into different species on the basis of minor characteristics which are considered merely as variations for specimens in the same zone, and notes that this course " . by some . . . is carried to such an extreme that the locality seems to be the chief guide to identification."

Further collections and studies are considered necessary before any definite conclusion on this problem can be reached.

Genus **Ancyrognathus** Branson and Mehl, 1933

Ancyrognathus irregularis Branson and Mehl

Plate II, figure 26

Ancyrognathus irregularis Branson and Mehl, 1933, Missouri Univ. Studies, vol. 8, no. 3, p. 242, pl. 19, figs. 1, 2, 4, 10, 16.

Plate broad, irregularly lobate anteriorly, oral surface ornamented with small nodes irregularly arranged, aboral surface with fine concentric lines and a bifurcating keel; carina prominent, composed of fused nodes, bifurcating near center of plate, the branches extending to the ends of the lobes; blade short, heavy, denticulate.

Hypotype, Ohio State University Geological Museum, no. 18417.

Genus **Bryantodus** Ulrich and Bassler, 1926

Bryantodus commutatus Huddle

Plate II, figure 6

Bryantodus commutatus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 70, pl. 2, figs. 13, 14.

Bar thick, rounded, moderately arched, curved laterally, with a faint keel extending along the entire length of the bar; cusp rather small, in some specimens indistinguishable from adjacent denticle; denticles fused except near tips, somewhat irregular in size, diminishing in length toward the ends of the bar.

Hypotype, Ohio State University Geological Museum, no. 18396.

Bryantodus concavus Huddle

Plate II, figure 5

Bryantodus concavus Huddle, 1934, Bull. Am. Paleontology, vol. 21, No. 72, p. 71, pl. 2, figs. 15–17.

Bar broad, smooth, laterally compressed, strongly arched; cusp long, thick at base, acutely pointed; denticles short, nearly parallel, confluent except at tips, six or eight on each side of cusp.

Hypotype, Ohio State University Geological Museum, no. 18397.

Bryantodus germanus Holmes

Plate II, figure 8

Bryantodus germanus Holmes, 1928, U. S. Nat Mus Proc , vol. 72, art. 5, p. 28, pl. 10, fig. 5.

Bar high, thin, slightly curved laterally but not arched, with a lateral ridge extending along its whole length, aboral edge sharp; cusp short, thick, rounded, inclined slightly; denticles short, close-set but not confluent, twelve anterior to cusp nearly vertical, six posterior to cusp slightly inclined.

Hypotype, Ohio State University Geological Museum, no. 18399

Bryantodus inequalis Holmes

Plate II, figure 10

Bryantodus inequalis Holmes, 1928, U S Nat Mus. Proc., vol. 72, art 5, p. 27, pl 10, figs. 1, 2. (Not *B. inequalis* Branson and Mehl, 1933, Missouri Univ Studies, vol. 8, p. 219, pl. 16, figs. 17, 18.)

Bar long, moderately arched, anterior half with prominent median ridge, posterior part thin, slightly curved laterally, aboral edge sharp, cusp short, broad, slightly recurved, inclined; denticles short, sharp-edged, close-set but not fused, ten to fourteen on each side of cusp, the anterior ones being larger and more inclined than those on posterior part of bar.

Remarks.—As noted in the synonymy, the specific name *inequalis* used by Branson and Mehl, was preoccupied by Holmes and a substitute should be proposed. (See Youngquist, 1945, p 358.)

Hypotype, Ohio State University Geological Museum, no 18400.

Bryantodus nitidus Ulrich and Bassler

Plate II, figure 11

Bryantodus nitidus Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 24, pl. 4, figs. 12–14.

Bar heavy, moderately arched, anterior part with prominent median ridge which extends along posterior part as a lateral expansion at base of denticles, aboral edge sharp with a slight expansion beneath cusp; cusp subcentral, rather short, thick, moderately inclined; long, slightly inclined denticles anterior to cusp; rather short, massive, vertical denticles posterior to cusp; all close-set but not confluent.

Hypotype, Ohio State University Geological Museum, no. 18401.

Bryantodus serrulus Huddle

Plate II, figure 14

Bryantodus serrula Huddle, 1934, Bull Am. Paleontology, vol. 21, no. 72, p. 71, pl. 2, figs. 18–20.

Bar moderately high and thick, slightly arched; cusp inclined, small, only slightly longer and thicker than the denticles; denticles numerous, small, inclined, close-set but not confluent, inserted, a few suppressed denticles present between bases of the developed denticles.

The aboral edges of the specimens observed are imperfectly preserved and therefore do not show characteristics of apical pit or groove.

Hypotype, Ohio State University Geological Museum, no. 18404.

Bryantodus subcarinatus Huddle

Plate II, figure 15

Bryantodus subcarinatus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 74, pl. 4, figs. 7, 8.

Bar long, thick, moderately arched, posterior part rounded, anterior part with prominent lateral ridge; cusp long, rather thin, inclined; denticles long, thin, straight, appressed but not confluent, seven to ten on each side of cusp, anterior ones vertical, posterior ones inclined.

Hypotype, Ohio State University Geological Museum, no. 18405.

Bryantodus subequalis Cooper

Plate II, figure 16

Bryantodus subequalis Cooper, 1931, Jour. Paleontology, vol. 5, p. 234, pl. 28, fig. 11.

Tooth very small, bar short, rather strongly arched; cusp proportionately large, inclined; denticles small, closely appressed and confluent, deeply inserted, four to six on each side of cusp, those anterior to cusp slightly curved and larger than the posterior denticles.

Hypotype, Ohio State University Geological Museum, no. 18406.

Bryantodus subplanus Huddle

Plate II, figure 17

Bryantodus subplanus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p 73, pl. 4, figs. 5, 6.

Bar thin, slightly arched; cusp long, slightly curved and inclined; denticles long, appressed, deeply inserted, minute suppressed denticles between large ones in central part of bar, anterior denticles large, slightly curved, five or six in number, decreasing in length anteriorly; posterior denticles near cusp thin and short, those near end of bar large.

Hypotype, Ohio State University Geological Museum, no. 18407.

Genus **Euprioniodina** Ulrich and Bassler, 1926

Euprioniodina prona Huddle

Plate I, figures 11, 12

Euprioniodina prona Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 52, pl. 6, fig 19; pl. 11, fig. 8.

Bar long, somewhat compressed, slightly arched, cusp short, round, thick at base but tapering to a sharp point, inclined strongly forward; anticusp wide, compressed, extending in line with cusp, bearing fine denticles which are close-set and inclined sharply upward; denticles on bar numerous, long, thin, slightly curved and inclined forward, minute denticles set between most of the larger ones.

The species is represented in this collection by clear impressions which closely resemble *Synprioniodina alternata* Ulrich and Bassler (1926, p. 42, text fig. 22 on p. 16). The distinction is made on the basis of the discrete bar denticles which are absent in the genus *Synprioniodina*, and also on the basis of the cusp and anticusp extending in a line as in ***Euprioniodina prona***.

Hypotypes, Ohio State University Geological Museum, nos. 18374, 18375.

Genus **Hibbardella** Ulrich and Bassler, 1926

Hibbardella angulata (Hinde)

Plate II, figure 9

Hibbardella angulata (Hinde), 1926, Ulrich and Bassler, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 37, pl. 3, figs. 1–4.

Bar highly arched, limbs moderately heavy, rounded, nearly straight; cusp long, thick, rounded, very slightly curved; denticles rather short, rounded, well separated, slightly curved toward the cusp, four or five on each side of the bar.

Hypotype, Ohio State University Geological Museum, no. 18409.

Genus **Hindeodella** Ulrich and Bassler, 1926

Hindeodella aculeata Huddle

Plate I, figures 19, 21

Hindeodella aculeata Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 40, pl. 4, figs. 19–21; pl. 5, figs. 2, 3.

Bar straight or slightly curved, long, thin, rounded, oral shoulder distinct, anterior portion of bar sharply curved laterally and slightly expanded downward; cusp rounded, curved and inclined posteriorly; denticles inserted, straight, rounded, inclined posteriorly, three or four small denticles between the large ones.

The oral shoulder distinguishes this species from *Hindeodella subtilis* Ulrich and Bassler (1926, p. 39, pl. 8, figs. 17–19).

Hypotypes, Ohio State University Geological Museum, nos. 18383, 18384.

Hindeodella alternata Ulrich and Bassler

Plate I, figure 23

Hindeodella alternata Ulrich and Bassler, 1926, U. S. Nat Mus. Proc., vol. 68, art. 12, p. 40, pl. 1, figs. 14, 15.

Bar straight or slightly arched, moderately thick, laterally compressed, anterior portion depressed and curved laterally; cusp long, thick, rounded, curved and inclined backward; several prominent posterior denticles progressively larger and more inclined posteriorly with one to three small denticles set between the larger ones, terminal denticles spine-like; anterior denticles large, slightly curved.

Although the species is represented in the material studied only by impressions, the large cusp and prominent posterior denticles with small denticles set between them are sufficient to identify the species. The form is distinguished from *H. germana* Holmes (1928, p. 25, pl. 9, fig. 9) by the progressive increase in size of the denticles posteriorly. The Ohio shale specimens, like the one from Montana figured by Cooper and Sloss (1943, pl. 29, fig. 18), lack the prominent terminal spine as developed in the cotypes.

Hypotype, Ohio State University Geological Museum, no. 18387.

Hindeodella germana Holmes

Plate I, figure 22

Hindeodella germana Holmes, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 25, pl. 9, fig. 9.

Bar rather short, thick, posterior part straight except for a slight downward deflection at the posterior end where it terminates in a spine-like point, anterior part bent sharply laterally and slightly curved downward; cusp long, slender; denticles ten to fifteen in number, less than half as long as cusp, straight, inclined posteriorly, one or sometimes two minute denticles set between large ones.

Hypotype, Ohio State University Geological Museum, no. 18386.

Hindeodella subtilis Ulrich and Bassler

Plate I, figure 25

Hindeodella subtilis Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 39, pl. 8, figs. 17–19.

Bar long, rather high and thick; posterior part straight or slightly arched, anterior part deflected downward slightly and curved sharply laterally; cusp long, nearly straight, inclined posteriorly; denticles numerous, small, alternating with three or four minute ones set between the longer ones except for those in front of the cusp which are irregularly arranged.

Hypotype, Ohio State University Geological Museum, no. 18388.

Hindeodella sp. 1

Plate I, figure 24

Bar probably thin, posterior part horizontally straight but slightly bowed laterally, anterior part deflected sharply downward and curved laterally, bearing four to six long denticles with several minute ones in between; cusp long, rounded, slightly curved posteriorly; denticles posterior to the cusp numerous, irregular in size and amount of inclination, generally progressively increasing in size and degree of inclination posteriorly, with fine denticles set between most of the large ones.

This form resembles *Hindeodella deflecta* Hibbard (1927, p. 207, fig. 4c), but the denticles are finer and more numerous than those of *H. deflecta*.

Figured specimen, Ohio State University Geological Museum, no. 18389.

Hindeodella sp. 2

Plate I, figure 20

Bar short, high, compressed, anterior part deflected slightly downward and curved laterally, posterior part straight, terminating in two short spine-like denticles; cusp prominent, slightly curved and inclined backward; anterior denticles large and slightly curved, posterior denticles rather small with two or three minute denticles set between somewhat larger ones.

This species is represented by two well defined impressions. Its characteristics suggest a new species, but a study of more material is necessary before positive relationships can be determined.

Figured specimen, Ohio State University Geological Museum, no. 18385.

Genus **Hindeodelloides** Huddle, 1934

This genus was established to include forms which differ from *Hindeodella* in the presence of a denticulate anticusp as developed in the genoholotype *Hindeodelloides bicristatus.* Whether this anterior downward projection is an anticusp or merely an excessive bending of the bar is a matter of question which throws doubt on the justifiability of retaining the genus. Ellison (1946, p. 108) suggests the need of additional research before a conclusion can be reached and states that the genus "probably belongs to *Hindeodella* Ulrich and Bassler."

The few specimens observed from the Ohio shale which closely resemble *Hindeodelloides bicristatus* Huddle show an anterior downward deflection and recurving of the bar rather than a development of an anticusp. The èvidence is not conclusive, however, and until better material can be studied, it seems best to assign these to the genus *Hindeodelloides.*

Hindeodelloides bicristatus Huddle

Plate I, figures 16, 17

Hindeodelloides bicristatus Huddle, 1934, Bull. Am. Paleontology, p. 48, pl. 7, figs. 2, 3; pl. 12, fig. 6.

Bar short, flattened, rather high, slightly curved, somewhat larger posteriorly than anteriorly; cusp prominent, long, slender, rounded, slightly curved and inclined posteriorly; denticles back of cusp close-set or appressed, straight and inclined posteriorly, minute denticles in between large ones; two or three prominent denticles on posterior part of bar, terminal denticles small; anterior downward projection (anticusp?) large, wide, and slightly recurved, bearing four or five large, up-curved denticles.

The specimens exhibit considerable variation in the length and thickness of the bar, and in the size and inclination of the cusp, but there is prominent similarity with respect to the large, recurved anterior downward projection and the prominent denticles on the posterior part of the bar. The species closely resembles *Hindeodella pumilla* Cooper (1931b, p. 236, pl. 28, fig. 18), but it lacks the long, slightly curved terminal denticle characteristic of that species.

Hypotypes, Ohio State University Geological Museum, nos. 18381, 18382.

Genus **Ligonodina** Ulrich and Bassler, 1926

The fundamental characteristics of the genus *Ligonodina* extend in three dimensions; therefore the features in the two-dimensional laminae surfaces are usually so incomplete that positive specific assignments cannot be made. The impressions described and figured in this paper are the most complete representatives of the dozen or so specimens studied.

Ligonodina sp. 1

Plate I, figure 10

Bar thin, moderately long, slightly curved; cusp long, laterally compressed, slightly curved backward; anticusp short with deep pits in the impression representing four or five denticles which extended from the anticusp at right angles to the plane of the bar and anticusp; bar denticles long, rounded, widely spaced, curved posteriorly, eight to ten in number, with minute denticles set singly between the larger ones on the posterior part of the bar. This form closely resembles *Ligonodina bicincta* Huddle (1934, p. 62, pl. 12, fig. 15).

Figured specimen, Ohio State University Geological Museum, no. 18378.

Ligonodina sp. 2

Plate I, figure 14

Bar short, straight, moderately thick; cusp long, rounded, slightly curved and inclined posteriorly; anticusp rather short, evidence of denticles on anticusp lacking; eight moderately long denticles on the bar with minute denticles set singly between the large ones. The impression shows a close similarity to *Ligonodina gouldi* Cooper (1935, p. 313, pl. 27, fig. 8).

Figured specimen, Ohio State University Geological Museum, no. 18380.

Ligonodina sp. 3

Plate I, figure 18

Bar long, thick, rounded; cusp long, rather thick, rounded, slightly curved posteriorly; anticusp not perfectly represented; bar denticles eight to ten in number, long, rounded, anterior ones apparently rather short, all curved and inclined posteriorly. The impression shows a general resemblance to *Ligonodina falciformis* Ulrich and Bassler (1926, p. 14, pl. 2, figs. 11–13).

Figured specimen, Ohio State University Geological Museum, no. 18379.

Genus **Lonchodina** Ulrich and Bassler, 1926

Lonchodina multidens Hibbard

Plate II, figure 3

Lonchodina multidens Hibbard, 1927, Am. Jour. Sci., 5th ser., vol. 13, p. 203, fig. 3i.

Bar thick, strongly arched, asymmetrical, anterior portion considerably longer than posterior part; cusp short, wide at base, situated near the apex of the arch; denticles curved upward, one or two minute ones set between most of the long ones; one posterior denticle nearly as long as cusp and somewhat more massive.

Hypotype, Ohio State University Geological Museum, no. 18393.

Lonchodina perarcuata Ulrich and Bassler

Plate II, figure 2

Lonchodina perarcuata Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 33, pl. 5, fig. 19.

Bar strongly arched, rather wide, with a faint lateral ridge; cusp large, rounded, slightly curved, situated at the apex of the arch; denticles quite short, round, anterior ones strongly curved upward, posterior ones almost straight, two of which are nearly equal in size to the cusp.

Hypotype, Ohio State University Geological Museum, no. 18394.

Lonchodina perlonga Ulrich and Bassler

Plate II, figure 4

Lonchodina perlonga Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 32, pl. 5, figs. 6, 7.

Bar slender, rounded, moderately arched; cusp long, slender, slightly curved; denticles widely separated, long, slender, similar to cusp, four to six on each side of cusp, those anterior to cusp curved, the others straight.

Hypotype, Ohio State University Geological Museum, no. 18395.

Genus **Metaprioniodus** Huddle, 1934

The genus *Metaprioniodus* was established to include forms similar to *Hindeodella* but distinguished by a posterior downward projection. Whether this characteristic is of generic or specific importance is questioned by Ellison (1946, p. 109) who recommends further research and suggests that *Metaprioniodus* probably belongs to *Hindeodella*. Pending further study it seems best to retain the genus *Metaprioniodus* for the two specimens collected from the Ohio shale which resemble very closely Huddle's genoholotype *Metaprioniodus biangulatus*.

Metaprioniodus biangulatus Huddle

Plate II, figure 1

Metaprioniodus biangulatus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 57, pl. 11, figs. 12, 13.

Bar short, heavy, deflected downward in posterior portion, anterior part deflected downward and curved laterally; cusp large, rounded, curved and inclined posteriorly; several long thin denticles anterior to cusp, back of cusp a number of long and slender denticles alternate with one or two minute ones; three large posterior denticles are sharply inclined backward.

The distinct oral shoulder characteristic of the genoholotype is not developed on the specimens under discussion.

Hypotype, Ohio State University Geological Museum, no. 18391.

Genus **Ozarkodina** Branson and Mehl, 1933

Ozarkodina delicatula (Stauffer and Plummer)

Plate II, figures 7, 12

Ozarkodina delicatula (Stauffer and Plummer) Ellison, 1941, Jour. Paleontology, vol. 15, p. 120, pl. 20, figs. 40–42, 47.

Blade thin, slightly arched, with a slightly flaring lip along aboral edge in some specimens; cusp short but very wide, suppressing adjacent denticles; denticles deeply inserted, appressed, confluent nearly to tips, decreasing in size quite regularly toward ends of blade, nearly vertical at anterior end of blade but progressively more inclined posteriorly.

Hypotypes, Ohio State University Geological Museum, nos. 18398, 18402.

Genus **Palmatodella** Ulrich and Bassler, 1926

Palmatodella delicatula Ulrich and Bassler

Plate I, figure 15

Palmatodella delicatula Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 41, pl. 10, fig. 5, text fig. 10 on p. 16.

Bar bent anterio-centrally forming a right angle, each limb thin and straight; main denticle or cusp at bend in bar extending nearly in line with posterior limb of bar, posterior denticles small, inserted, closely appressed, strongly inclined forward; anterior denticles long, inserted, closely appressed with a few diminutive suppressed denticles, all at right angles to bar and tapering in length, forming the characteristic palmate structure.

Hypotype, Ohio State University Geological Museum, no. 18377.

Palmatodella ? sp.

Plate I, figure 26

Bar long, straight or slightly arched, probably thin; cusp long, slender, inclined strongly forward, not distinct from denticles below it in some specimens; bar denticles eight or ten in number, vertical, closely appressed, very wide and short, probably bluntly pointed; denticles below cusp long, slender, closely set, extending forward in palmate arrangement usually aligned in the vertical plane with the bar and its denticles.

This species is represented by six clearly defined impressions of such similarity that there is reasonable assurance that the essential characteristics have been preserved. It is similar in its general aspect to *Palmatodella delicatula* Ulrich and Bassler (1926, p. 41, text fig. 20, p. 16), but differs in having very broad, short, vertical denticles on the bar, and in the extension of the palmate denticles from the anterior end of the bar rather than from a downward deflection. The form certainly represents a new species and probably a new genus, but definite relationships cannot be established until better material is collected and studied.

Figured specimen, Ohio State University Geological Museum, no. 18390.

Genus **Palmatolepis** Ulrich and Bassler, 1926

Palmatolepis glabra Ulrich and Bassler

Plate II, figure 25

Palmatolepis glabra Ulrich and Bassler, 1933, Branson and Mehl, Missouri Univ. Studies, vol. 8, no. 3, p. 233, pl. 18, figs. 9, 22, 26.

Plate long and narrow, curved sigmoidally, outline regular except for an abrupt truncation of one side of plate near posterior end, aboral surface marked with fine concentric lines and a thin median keel, oral surface finely pustulose; carina consisting of ten or twelve nodes anterior to the azygous node, and a rather high, thin, node-crested blade increasing in height posteriorly.

Hypotype, Ohio State University Geological Museum, no. 18416.

Palmatolepis quadrantinodosa Branson and Mehl

Plate II, figure 28

Palmatolepis quadrantinodosa Branson and Mehl, 1933, Missouri Univ. Studies, vol. 8, no. 3, p. 235, pl. 18, figs. 3, 17, 20.

Plate broad, subovate in outline, sigmoidally curved, oral surface ornamented with small to moderate-sized tubercles which tend to form rows extending perpendicular to carina; azygous node broadly conical; anterior part of carina straight, consisting of a few small nodes, posterior part curved, crested with small nodes, blade-like posteriorly.

Hypotype, Ohio State University Geological Museum, no. 18419.

Palmatolepis regularis Cooper

Plate II, figure 29

Palmatolepis regularis Cooper, 1931, Jour. Paleontology, vol. 5, p. 242, pl. 28, fig. 36..

Plate sigmoidal in outline, without lobes, pointed at both ends, oral surface minutely granulose, aboral surface almost smooth but showing very faint concentric lines, keel low and sharp; carina sigmoidally curved, crest nodose, probably high and blade-like posteriorly.

Hypotype, Ohio State University Geological Museum, no. 18420.

Palmatolepis subperlobata Branson and Mehl

Plate II, figure 27

Palmatolepis subperlobata Branson and Mehl, 1933, Missouri Univ. Studies, vol. 8, no. 3, p 235, pl. 18, figs. 11, 12.

Plate thin, broad, with wide lateral lobe, oral surface minutely granulose, aboral surface marked with fine concentric lines and small median keel; azygous node rounded, dome-like; carina back of azygous node is sharp, curved, with a faintly nodose crest, becoming high and blade-like posteriorly; the carina anterior to azygous node is low and faintly nodose; in some specimens a faint ridge branches from the carina and extends through the lateral lobe.

Hypotype, Ohio State University Geological Museum, no 18418.

Genus **Polygnathus** Hinde, 1879

Polygnathus nodocostata Branson and Mehl

Plate II, figure 22

Polygnathus nodocostata Branson and Mehl, 1933, Missouri Univ. Studies, vol. 8, no. 3, p. 246, pl. 20, figs. 9–13, pl. 21, fig. 15.

Plate subovate, slightly convex on oral side, marked with two or three rows of coalesced tubercles on each side of carina; carina prominent, extending full length of blade, slightly curved, marked with tiny nodes along crest; blade short, thick at base but with sharp crest.

Hypotype, Ohio State University Geological Museum, no. 18413.

Polygnathus pennatuloidea Holmes

Plate II, figure 21

Polygnathus pennatuloidea Holmes, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 32, pl. 11, fig. 14.

Plate subovate, oral surface convex, ornamented with irregularly arranged tubercles and a prominent, wide-based carina, crested with a series of nodes and extending the full length of the plate; blade long and thin. One specimen only, an impression of the oral surface of the plate, has been recognized.

Hypotype, Ohio State University Geological Museum, no. 18414.

Polygnathus sublatus Ulrich and Bassler

Plate II, figure 23

Polygnathus sublatus Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 47, pl. 8, fig. 2.

Plate ovate and somewhat curved, oral surface slightly convex, ornamented with rows of small tubercles arranged in radial rows; carina broad, low, faintly nodose; plate thin, probably long.

The species is represented by a single impression of the oral surface of the plate.

Hypotype, Ohio State University Geological Museum, no. 18415.

Polygnathus sp.

Plate II, figure 20

Plate ovate, slightly curved, somewhat constricted on one side near anterior end; aboral surface marked with fine concentric lines, a sharp median keel, and an escutcheon; oral surface not known; blade long, thin.

Represented by an impression of the aboral side of the plate and therefore lacking sufficient evidence for specific designation.

Figured specimen, Ohio State University Geological Museum, no. 18412.

Genus **Prioniodina** Ulrich and Bassler, 1926

Prioniodina separans Holmes

Plate I, figure 27

Prioniodina separans Holmes, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 27, pl. 9, figs. 16, 17.

Bar long, rounded, moderately arched, posterior part slightly offset laterally at cusp; cusp long, slender, very slightly curved, inclined posteriorly; denticles long, thin, almost straight, widely separated, anterior denticles larger than posterior ones.

Hypotype, Ohio State University Geological Museum, no. 18392.

Genus **Prioniodus** Pander, 1856

Prioniodus alatoides Holmes

Plate I, figures 5, 7

Prioniodus alatoides Holmes, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 24, pl. 9, fig. 3.

Bar straight, narrow, of nearly uniform proportions throughout its length; cusp long, slim, slightly tapered, inclined forward; anticusp short, triangular in outline, distinctly flattened posteriorly, anterior edge essentially in line with anterior edge of cusp; denticles large, long, and tapering, discrete, inclined slightly forward, numbering ten to fourteen. The presence of minute suppressed bar denticles is indicated in some clear impressions as represented in figure 7, Plate I. In the anterior margin of the anticusp small germ denticles are faintly visible in well preserved specimens. They are distinct in weathered specimens and in some impressions.

Hypotypes, Ohio State University Geological Museum, nos. 18369, 18371.

Prioniodus alatoideus Cooper

Plate I, figures 4, 6

Prioniodus alatoideus Cooper, 1931, Jour. Paleontology, vol. 5, p. 232, pl. 28, fig. 1.

Tooth small with thin, flat, straight bar; cusp long, slim, slightly tapered, inclined forward; anticusp short, subtriangular in outline, flattened toward both edges; denticles numerous, long, slender, inserted and confluent nearly to tips, slightly inclined forward. Minute germ denticles are inserted in anterior edge of anticusp.

The specimens from the Ohio shale compare favorably in size with the holotype and with Cooper's and Sloss's hypotypes (1943, pl. 29, figs. 6, 7, 11), but they are less than half as large as the hypotypes described by Huddle (1934, p. 37, pl. 1, figs. 4, 5) and by Cooper (1939, p. 404, pl. 45, fig. 62; pl. 46, fig. 19). The short, thick bar represented in the fossil impression illustrated in figure 4 is considered a variation within the species. (Cf. Cooper and Sloss, 1943, pl. 29, fig. 6.)

The species is distinguished from *P. alatoides* Holmes (1928, p. 24, pl. 9, fig. 3) on the basis of its numerous, fine, inserted and confluent denticles.

Hypotypes, Ohio State University Geological Museum, nos. 18368, 18370.

Prioniodus alatus Hinde

Plate I, figure 9

Prioniodus ? alatus Hinde, 1879, Geol. Soc. London, Quart. Jour., vol. 35, p. 361, pl. 16, fig. 5.

Bar straight, thick, high, aboral edge sharp; cusp massive, broad, compressed, sharp-edged, inclined forward, projected below bar to form a rather short, triangular anticusp, anterior edge of cusp and anticusp forming a straight line; denticles closely appressed, deeply inserted, free only at tips, regularly decreasing in size posteriorly, a few minute suppressed germ denticles visible between embedded portions of developed denticles.

Hypotype, Ohio State University Geological Museum, no. 18373.

Prioniodus cultratus Ulrich and Bassler

Plate I, figure 8

Prioniodus cultratus Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc. vol. 68, art. 12, p. 9, pl. 9, fig. 7.

Bar short, straight, and rather thin; cusp vertical, long, broad, compressed, sharp-edged; anterior edge straight and posterior edge curved giving the effect of a slight forward inclination; anticusp very small, representing merely an anterior expansion of the bar to meet the slight aboral projection of the anterior edge of the cusp; denticles long, straight, slightly inclined posteriorly, ten or twelve in number, inserted, basal portions closely appressed but upper two-thirds discrete, a few suppressed denticles between developed ones.

The large, broad, compressed, vertical cusp is distinctive of this species. The specimens in the collection studied resemble the specimen figured by Holmes (1928, p. 24, pl. 9, fig. 4) but differ from those figured by Cooper (1931a, p. 146, pl. 20, fig. 2; 1935, pl. 27, fig. 4) in that his fossils show a thin, recurved cusp and curved denticles quite widely separated on the bar.

Hypotype, Ohio State University Geological Museum, no. 18372.

Genus **Spathognathodus** Branson and Mehl, 1941

Genus *Spathodus* Branson and Mehl, 1933, Missouri Univ. Studies, vol. 8, no. 1, p. 46.
Genus *Spathognathodus* Branson and Mehl, 1941, Jour. Paleontology, vol. 15, p. 98.

Spathognathodus subrectus (Holmes)

Plate II, figure 19

Panderodella subrecta Holmes, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 31, pl. 10, fig. 15.
Spathodus subrectus (Holmes) Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 91, pl. 7, fig. 17.

Bar high, nearly straight, aboral expansion situated near anterior end; denticles short, confluent except at tips, subequal in size, slightly longer at posterior end of bar than at anterior end.

Hypotype, Ohio State University Geological Museum, no. 18410.

Genus **Subbryantodus** Branson and Mehl, 1933

Subbryantodus radians Branson and Mehl

Plate II, figure 13

Subbryantodus radians Branson and Mehl, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 141, pl. 34, figs. 22, 23.

Bar short, high, rather thick, moderately arched, aboral edge sharp except for small expansion beneath cusp; cusp short, very wide at base and sharply pointed, thus having a triangular outline; it is inclined and tends to suppress the adjacent posterior denticles; denticles close-set but not confluent, inclined, inserted, posterior ones about half as large as anterior ones, four to six on each side of cusp.

This form is much smaller than the holotype, but the proportionately large cusp, the few denticles, and small aboral expansion below cusp relate it to the species.

Hypotype, Ohio State University Geological Museum, no. 18403.

Subbryantodus sp.

Plate II, figure 18

Tooth small, bar strongly arched, rather high, anterior part thin, straight-sided, laterally straight, posterior part somewhat rounded and curved laterally, apical pit and aboral grooves distinct; apical denticle slightly inclined, short, broad, not sharply distinguished from other large denticles; denticles short, broad, closely appressed, some overlapping, deeply inserted, with minute germ denticles visible deep within bar, small denticles alternating with the large ones on anterior part of bar.

The single specimen of the species in this collection resembles the paratype of *Subbryantodus radians* Branson and Mehl (1938, p. 141, pl. 34, fig. 22), but it lacks the prominent apical denticle characteristic of the species. Additional material is necessary before specific assignment can be made.

Figured specimen, Ohio State University Geological Museum, no. 18408.

Genus **Synprioniodina** Ulrich and Bassler, 1926

Synprioniodina sp.

Plate I, figure 13

Bar short, slightly arched; cusp rather small, flattened, wide at base but tapering rapidly to a sharp point, inclined strongly forward; downward projection of bar (anticusp?) long, broad at base and tapering to a point resulting in a triangular outline; bar denticles fifteen or twenty in number, of medium length, slender, closely set, sharply pointed, curved anteriorly and decreasing in size posteriorly; two or more large denticles closely set in front of cusp, smaller denticles along anterior edge of downward projection, decreasing in size downward, inclined strongly upward.

The few specimens of the species in this collection are impressions, and these indicate distinct features which suggest an undescribed species. However, it is thought best to defer definite assignment until more material can be obtained for study purposes.

Figured specimen, Ohio State University Geological Museum, no. 18376.

DERMAL PLATES

Plate II, figures 24, 30

Black, lustrous plates, rather thin, rhomboid in outline, two margins marked by fine striae which produce a feather-edge effect, surfaces containing small depressions which are elongate longitudinally and irregularly spaced. The plates are of various sizes and dimensions ranging in length from 1.5 to 2.5 mm.

These plates are presumably parts of the protective armour of some type of fish or fish-like animal, but at the present time it is impossible to tie them up with anything definite. Their association with conodonts suggests a morphological relationship.

Figured specimens, Ohio State University Geological Museum, no. 18421.

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AN ECOLOGICAL STUDY OF THE SPIDERS OF A RIVER-TERRACE FOREST IN WESTERN TENNESSEE[1]

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Studies dealing with the ecology of spiders are of two main types: (1) those which give ecological consideration to the entire animal population of the habitat and the spiders incidentally as members of that population, Adams (1915), Weese (1924), Blake (1926), and (2) those which give intensive consideration to the ecology of spiders exclusively of a particular habitat, Elliott (1930), Truman (1942). This study is of the latter nature.

PROCEDURE AND SCOPE OF WORK

Spiders were collected continuously every ten to fourteen days over a period of twenty-two months in a River-Terrace forest located along the secondary terrace of the Wolf river, a tributary of the Mississippi, in the region of Memphis, Tennessee. The land adjacent to the Mississippi River and its tributaries is characterized by typical swamp forest vegetation. As the land rises from the flood plain level, a secondary terrace forest is apparent, composed essentially of an Oak-Gum community along the lowland and Oak-Hickory along the upland, drier portion. Collections were made by beating branches of trees and shrubbery, sweeping herbage, sifting leaves and upper soil layer and removing the bark and wood from trees, stumps and logs. Species were identified by Dr. W. M. Barrows, of the Ohio State University.

THE SPIDER POPULATION OF THE RIVER-TERRACE FOREST

Species inhabiting the forest are listed alphabetically and numbered consecutively in order that they may be referred to by their numerical position in the table which appears below. The names given to the spiders are those, as far as possible, listed in the synonymic Index-Catalogue of Spiders of North, Central and South America (Petrunkevitch).

1. *Acacesia foliata* Hentz.
2. *Agassa cyaena* Hentz.
3. *Agelena americana* Keyserling.
4. *Agelena emertoni* Chamberlin & Ivie.
5. *Agelena naevia* Walckenaer
6. *Agroeca* sp. ?
7. *Amaurobius americana* Keyserling.
8. *Antistea* sp.?
9. *Anyphaena fraterna* Banks
10. *Anyphaena saltibunda* Hentz
11. *Araneus arenatus* Walckenaer.
12. *Araneus benjaminus* Walckenaer.
13. *Araneus marmoreus* Clerck.
14. *Araneus miniatus* Walckenaer.
15. *Araneus stellatus* Walckenaer.
16. *Araneus thaddeus* Hentz.
17. *Araneus tusus* Petrunkevitch.
18. *Arctosa* sp ?
19. *Argiope aurantia* Lucas.
20. *Argiope trifasciata* Forskal.
21. *Argyrodes trigonum* Hentz.
22. *Argyrodes trituberculatus* Becker.
23. *Ariadne bicolor* Hentz.
24. *Aysha gracilis* Hentz
25. *Bathyphantes micaria* Emerton.
26. *Callilepis imbecilla* Keyserling.
27. *Castaneira longipalpis* Hentz.
28. *Castaneira stupkai* Barrows.
29. *Ceraticelus fissiceps* Cambridge.
30. *Ceraticelus micropalpis* Emerton.

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31. *Ceraticelus minutus* Emerton.
32. *Ceratinopsis* sp.?
33. *Cesonia bilineata* Hentz.
34. *Chiracanthium inclusum* Hentz.
35. *Cicurina itasca* Chamberlin & Ivie.
36. *Clubiona pallens* Hentz.
37. *Crustulina guttata* Wider.
38 *Cyclosa conica* Pallas.
39. *Dendryphantes* (P) *audax* Hentz.
40. *Dendryphantes* (*M*) *capitatus* Hentz.
41. *Dendryphantes insignarius* Koch.
42. *Dendryphantes* (*P*) *whitmanii* Pecham.
43. *Dictyna armata* Banks.
44. *Dictyna bicornis* Emerton.
45. *Dictyna cruciata* Emerton.
46. *Dictyna frondea* Emerton.
47. *Dictyna sublata* Hentz.
48. *Dictyna foliacea* Hentz.
49. *Dictyna zaba* Barrows and Ivie.
50 *Dipoena nigra* Emerton.
51 *Dolomedes* sp ?
52 *Drassodes* sp.?
53 *Drasyllus aprilinus* Banks.
54. *Drasyllus divinus* Chamberlin
55 *Drasyllus fallens* Chamberlin.
56 *Drexelia directa* Hentz
57 *Ebo latithorax* Keyserling
58 *Epeira juniperi* Emerton
59 *Erigone autumnalis* Emerton.
60 *Eperigone maculata* Banks.
61. *Ero* (*furcatus?*) Villers
62. *Euryopis funebris* Hentz.
63 *Eustalia anastera* Walckenaer.
64. *Fuentes lineatus* Koch.
65. *Gea heptagon* Hentz.
66. *Gnaphosa bicolor* Hentz.
67. *Hahnia brunnea* Emerton.
68 *Harbrocestum pulex* Hentz.
69. *Hentzia basilica* McCook
70. *Herpyllus vasifer* Walckenaer.
71. *Hyctia* sp.?
72. *Kaira alba* Hentz.
73. *Lepthyphantes sabulosa* Keyserling.
74. *Leucage venusta* Walckenaer.
75 *Linyphia communis* Hentz.
76. *Linyphia lineata* Linnaeus.
77. *Litopyllus rupicolens* Chamberlin.
78. *Loxosceles* (*rufescens?*) Dufour.
79. *Lycosa avara* Keyserling.
80. *Lycosa punctulata* Hentz.
81. *Lycosa rabida* Walckenaer.
82. *Maevia vittata* Hentz.
83. *Mangora gibberosa* Hentz.
84. *Mangora placida* Hentz.
85. *Marpissa undata* DeGeer.
86. *Micaria* sp.?
87. *Micrathena gracilis* Walckenaer.
88. *Micrathena reduviana* Walckenaer.
89. *Microneta cornupalpis* Cambridge.
90. *Microneta latidens* Emerton.
91. *Mimetus* sp.?
92 *Misumenops asperatus* Hentz
93. *Misumenops celer* Hentz.
94. *Misumenops oblongus* Keyserling.
95 *Oedothorax* sp ?
96. *Originates rostratus* Emerton.
97. *Oxyopes aglossus* Chamberlin.
98. *Oxyopes salticus* Hentz.
99 *Pachylomerus* sp ?
100 *Pardosa nigropalpis* Emerton.
101. *Pechamia scorpionea* Hentz.
102 *Pallenes* sp.?
103. *Philodromus minutus* Banks.
104 *Philodromus pernix* Blackwell.
105 *Phlegra fasciata* Hahn.
106 *Phrurolithus alarius* Hentz.
107. *Phrurolithus divinulus* Gertsch.
108. *Phrurolithus dulcineus* Gertsch.
109. *Pirata arenicola* Emerton.
110. *Pirata minutus* Emerton.
111 *Pisaurina mira* Walckenaer.
112. *Sergolius variegatus* Hentz.
113. *Schizocosa crassipes* Walckenaer.
114. *Scoloderus tuberculifer* Cambridge.
115. *Sittious cursor* Barrows
116 *Synaema parvulum* Hentz.
117. *Tapinopa bilineata* Banks.
118 *Tetragnatha laboriosa* Hentz
119. *Thanatidius dubius* Hentz.
120. *Theridion differens* Emerton
121. *Theridion dulcineum* Gertsch & Archer.
122 *Theridion frondeum* Hentz.
123. *Theridion globosum* Hentz.
124. *Theridion kentuckyense* Keyserling
125. *Theridula opulenta* Walckenaer.
126 *Theridion studiosum* Hentz.
127. *Theridion wallacei* Gertsch & Archer.
128. *Thiodina sylvana* Hentz.
129. *Tmarus* (*angulatus?*) Walckenaer.
130. *Tmeticus* (*asetivalis?*)
131. *Trachelas tranquillas* Hentz.
132. *Uloborus americanus* Walckenaer.
133. *Wala mitrata* Hentz.
134. *Wala palmarium* Hentz
135. *Xysticus ferox* Hentz.
136. *Xysticus funestus* Keyserling
137. *Zelotes hentzi* *M.S.S.* W. M. Barrows
138 *Zygoballus bettini* Pecham.
139. *Zygoballus sexpunctatus* Hentz

ECOLOGY OF THE RIVER-TERRACE FOREST SPIDERS

A summary of the findings with reference to ecological factors is given below in tabular form. Blank spaces in the table indicate insufficient data for the determination required. The symbols used in the table are as follows:

COLUMN I—Species as indicated by numbers given in the taxonomic listing on pages 38 and 39. A "D" alongside of the number representing the species indicates that the species characteristically inhabits the more moist lowland portion of the forest.

COLUMN II—The number of individuals collected of a particular species.

COLUMN III—Specific relation of the species to the forest. These determinations are based upon a comparative study made between species of spiders inhabiting this forest and those recorded for vegetational associations such as Oak-Hickory, Beech-Maple, Elm-Maple, Wet and Dry Prairie, etc. Also upon numerous collections made along the margins of the forest, the adjacent fields and meadows and other similar forests of the region. Symbols used in column III are:

R—Species typical of the River-Terrace forest.
E—Species usually found along the forest border or in regions where cutting of trees has resulted in a mixed grassland-forest community.
F—Field spiders, those found most often and in greatest numbers in cultivated areas, meadows or grassland.
Fo—Species reported for all forests on which data have been compiled and therefore exhibiting no habitat specificity in this regard.
O—Spiders which though present in the River-Terrace forest are more typical of Oak-Hickory.
Pw—Species characteristically inhabiting the wet prairie.
Pd—Species characteristically inhabiting the dry prairie.
Be—Spiders more typical of Beech-Maple and River-Terrace forest.

COLUMN IV—Characteristic stratal position of the spider population within the forest during the warm part of the year. Symbols used in column IV are:

G—Ground stratum.
H—Herb stratum.
S—Shrub stratum.
A—All strata.
U—Upper strata (herb-shrub-tree).
B—Species found characteristically under or in the crevice of bark.

COLUMN V—Approximate hatching periods for the species. (Suggested periods are good only for the vicinity of Memphis, Tennessee.) The determinations were made by comparing younger and younger stages of various species and by keeping the egg sac of others until hatching occurred. Though the suggested hatching periods are approximations in certain instances, the list is presented in the hope that it will stimulate further investigation on the part of those ecologically minded with resulting verification and necessary correction. Symbols: The months are numbered according to their occurrence in the year.

E—indicates the first half of the month.
M—indicates the mid-portion of the month.
L—indicates the last half of the month.

COLUMN VI—Period during which species matures. Symbols are the same as in Column V.

COLUMN VII—Hibernation stage of the species. In general the determination of the hibernation stage rests upon the mid-winter collection of spiders. Symbols used in Column VII are:

I—spiders that hibernate in immature or adult form.
E—spiders that overwinter in the egg sac as eggs or very young.

TABLE I

I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII
1	16	E	H	9E	7L	E	8	2	......	G?	......	......	......
2D	1	R	G	.....	......	......	9	613	R	A	6M	5M	I
3	214	F	A	9E	7M	E	10	237	E	A	6M	5E	I
4	20	F	A	9E	7M	E	11	15	Fo	T	8L	6L	I
5	82	F	A	9E	7M	E	12	18	O	S	8L	6L	I
6	1	......	H?	...	......	.....	13	1	Fo	S	......	......	E
7	3	Fo	G	6M	5E	I	14	2	R	S	......	......	I

TABLE I—(*Continued*)

I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII
15	33	F	H	8L	6M	I	78D	2	R	S	...	...	...
16	11	R	T	8L	6L	I	79	157	Rw	G	6E	4E	I
17	8	R	A	8L	6M	I	80	2	.	G	.	...	E
18	13	...	G?	.	...	I	81	75	E	GH	9L	7L	E
19	8	E	HS	4L	8L	E	82	69	E	H	7E	5L	I
20D	17	E	U	4M	8L	E	83	33	E	H	8L	6L	I
21	3	.	S	...	.	I	84	86	R	H	7E	6L	I
22	2	R	S	...		I	85	17	O	B	7M	5E	I
23S	58	Fo	G	5M	4E	I	86	4			...	...	
24	118	O	A	6M	E5	I	87	1	E	T?		.	...
25	7	E	H	...		I	88	2	R	.		.	...
26	71	E	GH	6M	5E	I	89	4	Be	G	5L	4M	I
27	6	Fo	G	8L	6L	.	90	3	R	G	5L	4M	I
28	8	R	G	8M	7L	E	91	15	R	H	...		I
29	4	R	H	6M	5E	I	92	70	Fo	A	6E	5L	I
30D	1	R	G	...	...	...	93	19	R	U	6E	5L	I
31	3	Fo	H	6E	4L	I	94	24	E	U	6E	5L	I
32?	1	...	...	...	...	...	95?	1			.	...	...
33	3	R	H	8L	6L	I	96	4	R	TS	.	...	I
34	12	R	H	6M	4M	I	97	239	R	A	7E	6M	I
35	1	R	G	...	...	.	98	119	E	H	7L	5M	I
36	36	Fo	G	6M	5L	I	99?	...	...	...	...	.	...
37D	1	E	G?	.		...	100D	14	E	G	5M	4L	I
38	3		S	6M	5E	I	101?	2	F	.	.		...
39	72	E	U	7E	5L	I	102	3	.	.	...		...
40	18	E	SH	HL	7E	I	103	11	R	T	6M	5E	I
41	179	R	A	7E	5L	I	104	39	O	A	6M	5E	I
42	51	O	A	...	...	I	105	1	R	G	.	.	...
43	20	R	G	6M	5E	I	106	143	Fo	G	6M	5E	I
44	3	R	G	6M	5E	...	107	4	.	G	...		...
45	135	R	U	6M	5E	I	108	1	F	G	...	...	...
46	23	F	H	6M	5E	I	109	6	R	G	7E	5L	I
47	11	E	H	6M	5E	I	110	16	F	G	7E	5L	I
48	65	E	SH	6M	5E	I	111	286	E	H	8L	6M	I
49	177	E	A	6M	5E	I	112	2	R	H	7E	5M	I
50	1	...	...	...	...	...	113	57	E	GH	5M	4E	I
51?	1	...	...	...	...	...	114	18	R	U	8L	6L	I
52	1	...	...	...	.	...	115D	1	F	.	...	...	...
53	1	...	G?	.		...	116	7	O	GH	5M	8M	I
54	2	R	G	6M	5E	I	117	2	...	A	...	...	...
55D	24	R	G	6M	5E	I	118	121	E	H	7E	6M	I
56	2	Pd	H	...	...	I	119	115	R	A	7E	5L	I
57	64	R	GH	6E	4L	I	120	22	E	U	6E	5E	I
58D	7	Fo	T	10L	7L	...	121D	1	R?	...	...	...	...
59	6	E	U	4L	9L	I	122	5	E	H		...	...
60	1	...	G?	...	...	...	123	42	R	H	6M	5E	I
61	1	...	...	...	...	...	124	4	R	T	...	...	...
62	5	Fo	U	6M	5E	I	125	33	E	A	8E	7M	I
63	23	Fo	HS	8E	5L	I	126D	63	R	T	7E	6M	E
64	31	E	G	7M	6E	I	127	2	...	G	.	...	...
65	5	R	H	8M	6L	I	128	90	R	A	7E	5E	I
66	2	E	G	...	...	...	129	3		...	...	...	...
67D	6	R	G	8L	L6	I	130	3	...	G	...	...	...
68D	9	E	A	6M	4M	I	131	4	E	...	8L	6L	I
69D	9	R	U	8L	6L	I	132	49	Fo	H	9L	8E	I
70	6	Fo	A	6M	5E	I	133	8	R	S	6M	5M	I
71?	1	...	...	...	...	...	134	2	O	T	...	...	I
72	7	R	H	6M	5E	I	135	31	E	GH	6M	4L	I
73	20	R	G	9L	8E	I	136	33	E	GH	6L	4L	I
74	80	Fo	U	7L	6L	E	137	6	E	G	8L	6L	I
75	40	F	H	6M	5E	I	138	1	R	H	...	...	I
76	101	F	H	6M	5E	I	139	28	R	H	6L	4L	I
77	1	...	G	...	...	...							

THE HABITAT

The River-Terrace forest, like the Deciduous forest in general, presents well defined strata. These are forest floor, herb layer, shrub layer and forest crown. Because of the influence of the forest crown and the absence of conditions such as exist in associations like arctic tundra and desert, environmental conditions are more uniform. Habitat situations within the forest, as pertaining to spiders, primarily reflect differences associated with the various vegetational strata from forest floor to forest crown. It is axiomatic that soil temperatures in general and especially forest soil temperatures are more stable than the overlying atmospheric temperature. Periodic checks of temperature, light and humidity in the strata of the forest under investigation substantiated the observations made by Weese, Blake and others that the forest floor has the lowest temperature of the strata generally during the summer, and highest during the winter. Humidity is greatest and light intensity lowest at the forest floor. The rate of evaporation was not checked, but it may be assumed that the evaporation rate is least at the ground-leaf layer. Weese (1924) has given proof of this for the Elm-Maple forest which he investigated. From the forest floor upward light intensity, temperature and evaporation increases while humidity decreases. Fluctuations in these physical factors of the environment occurs least in the ground-leaf layer and most in the forest crown, the reasons for this have been fully explained by Adams (1915), Weese (1924) and Blake (1926).

Spiders inhabiting the ground-leaf layer are species tolerant of little light, comparatively low temperature, a fair degree of moisture and low evaporation. The population of this stratum is the most constant of all the strata except during the winter months when migrants characteristic of other situations hibernate in it. This constancy of population is associated with physical factor gradients which exist between the ground-leaf layer and the adjacent herb layer. Spiders passing from one of these strata to the other undergo marked and sometimes very sharp changes.

Similar differences exist with regards to herb, shrub and tree strata but the gradients are not as steep nor as controlling in their effect.

The transitional nature of the forest under investigation affords a more varied habitat than more homogeneous vegetational associations such as Oak-Hickory or Beech-Maple forests because the River-Terrace Forest gradually changes from the more dense humid and shady forest of the lowland to the drier, more open Oak-Hickory association of the upland. Also, the presence of prairie vegetation in certain regions of the area adds further to the diversified nature of the habitat. Correlated with these varied biotic and physical features, there is much diversification in the spider population.

DISCUSSION

The stratal and habitat relations given above are not intended to indicate that the spiders are limited to the designated situations, but that the particular species are found most often and in greatest numbers in the micro-habitat or habitat suggested. Some of the spiders are apparently tolerant of a wide variety of conditions and can be found virtually in all situations in substantial numbers. Comparative abundance alone cannot be used as a criterion for determining habitat preferences, as the table shows, it often happens that a species characteristic of one habitat is numerically dominant in another; for example, ***Agelena naevia***—a field form—and ***Pisaurina mira***—a transitional form—are among the most numerous in the River-Terrace forest.

Physical factors are the dominant forces in the activities of the spiders during the winter. The habitat is essentially reduced to a single layer, the ground-leaf stratum. In southern Tennessee, however, a few species can be collected from the remnant herb layer throughout the winter. As pointed out by Weese (1924), preceding hibernation there is a general downward migration of the spiders but certain species such as *Clubiona pallens* and *Ariadna bicolor* move upward with the advent of winter and hibernate under the bark of trees. Activity is reduced to a minimum during hibernation except on warm days when certain species move about on the dead leaves and herbs but even then evidence of predatory activity is lacking.

The mass hatchings indicated in the table during the late spring and the late summer result in two population peaks in the population density of the spiders when the young hatched at these periods mature The fact that the hatching period and time of maturity of the species given above are somewhat earlier than published reports in this regard for the same species farther north, and that species reported as overwintering as eggs or egg-sized spiders in the north are readily collected from one-fourth to one-half grown in the Memphis area indicate the effect of environment on the reproductive and developmental processes of the spiders.

SPECIES DIAGNOSTIC OF THE HABITAT

Only thirty species were represented by fifty individuals or more in the collections. The total number of individuals of these thirty species constitute more than three-fourths of the 5,090 spiders taken. Among these principal or numerically dominant groups were some more typical of other habitats as the table shows. However, it is interesting to note that certain of these principal species occur in great abundance in this forest while being very scarce or absent in other vegetational communities studied Further, according to published reports and information gained from collectors, one of the species (*Oxyopes aglossus*) though widely distributed, seems to be found in large numbers only in this type of habitat. Species of this nature are: *Oxyopes aglossus, Anyphaena fraterna, Thiodina sylvana, Mangora placida, Dictyna cruciata, Theridion studiosum* and *Ebo latithorax*. Collectively, they are diagnostic of the River-Terrace forest

SUMMARY AND CONCLUSION

Although a great variety of species inhabit the forest, a comparatively few species make up the largest part of the total number of individuals collected. One hundred and thirty-nine species of spiders are reported for the forest. Thirty species, or approximately one-fifth of the total number, constitute 4,007 individuals or over three-fourths of the 5,090 individuals collected.

Principal species numerically are not always spiders typical of the forest, but may be forms more characteristic of other situations such as the forest border or field

Of the spiders whose habitat relations were determined, 46 were typical River-Terrace forest spiders; 24 were forest spiders but more typical of other forests (Beech-Maple, Oak-Hickory, Elm-Ash-Maple, etc.); 33 were transitional forms and 11 were field spiders.

Seven species which we consider particularly diagnostic of the River-Terrace forest have been listed.

During the warm part of the year vertical distribution of the species is characterized by stratal communities. Stratification is associated with the physical factors and the vegetation.

Species composition of the stratal communities is not constant but shows seasonal variation.

Horizontal distribution is largely associated with varying moisture content of the soil.

Most of the spiders hibernate as immature forms or adults. Only 14% of the spiders whose hibernation stage was determined overwinter as eggs or egg-size spiders.

Over 90% of the species hibernate in the ground-leaf stratum, thus preceding hibernation there is a general downward migration. Apparently temperature is the chief factor affecting this vertical shifting.

The spiders exhibit two major hatching periods, late spring and late summer.

The mass hatchings of late spring and late summer result in two population peaks of adults when the spiders hatched at these times have matured.

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SOME NEW SPECIES OF IDIOCERUS (HOMOPTERA—CICADELLIDAE) FROM THE UPPER MISSISSIPPI VALLEY

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The species of Idiocerus have been distinguished primarily upon the basis of color markings. Some significance has been given to the size and type of antennal discs which are differential in the males. In view of the use of color characteristics it is apparent that two or more species which have no color markings or which are very similarly marked have been included under a single name. During the past few years the genital structures of the males have been used to separate these similar forms into species but it has been necessary to determine or select the species already described. Through the assistance and cooperation of Dr. Paul Oman, Curator of Hemiptera, U. S. Nat. Musuem, lectotypes have now been selected from the type series and specific morphological characters have been established for I. *pallidus*, *nervatus*, *alternatus* and *lachrymalis*. Illustrations of these characters will be published in a subsequent article.

In order that the names of six of these new species previously placed under the names mentioned above may be used in a completed manuscript covering the faunal study of a geographic area it seems advisable to describe this limited group of species at the present time and illustrate the characters by which they may be recognized.

Idiocerus telus n. sp.

Resembling *pallidus* in form and appearance but with different male genitalia. Length, 5 mm.

White tinged with green without dark markings, basal angles of scutellum yellowish. Elytra subhyaline, veins tinted with green. Face pale. Antennal discs large, black, ovate.

Genitalia: Male plates elongate, rather narrow. Styles slightly broadened near apex,then rapidly narrowed to a pointed apex. Each style bears a prominent spine just before apex. Ventral portion of aedeagus tapered from base to apical fifth which is broadened by a pair of prominent spines which are "webbed" to the main aedeagus shaft. These spines slope almost to apex giving the head portion a triangular appearance, with a blunt apex. The dorsal portion is shorter and constricted at middle between a rather broad base and a broader, diamond shaped apex. The latter has a pointed apical margin, and a broadened pointed lateral margin on each side.

Holotype male and paratype male collected at Pike, Ill., June 28, 1934, by DeLong and Ross. Holotype in Illinois Natural History Survey Collection.

Idiocerus incomptus n. sp.

Resembling *nervatus* in form and coloration but with distinct male gentalia. Length 4.5 mm

Color pale green to yellow green without markings except pale brownish spots on basal angles of scutellum. Elytra subhyaline with pale veins. Dark veins of under wings conspicuous from above. Face pale, slightly infuscated above.

Antennal discs slightly enlarged, elongate, black at apex.

Genitalia: Male plates elongate, rather narrow, apices broadly rounded. The styles are rather narrow and are tapered about two thirds of their length to form pointed apices each of which bears a large spine. The ventral portion of the aedeagus is only slightly narrowed from base to apex, the latter of which is rounded and bears a short spine either side about one fifth the distance from the apex. The dorsal portion of the aedeagus is constricted at the middle forming a rounded portion at the base which is distinctly wider than the ventral process and a smaller rounded portion just slightly wider than the ventral process at the apex; this terminates just anterior to the spines of the ventral process.

Holotype male collected from cypress at Horseshoe Lake, Illinois, July 11, 1935, by DeLong and Ross.

Holotype in Illinois Natural History Survey Collection.

Idiocerus apertus n. sp.

Form and general appearance of *nervatus* but pale brownish in color. Length male 4.5 mm.

Vertex broadly rounded, a little shorter at middle than next the eyes. Color, yellowish tinted with brown. The central portion of vertex brownish. Disc of pronotum, basal angles of scutellum, and basal portion of elytra tinted with brown. Elytra subhyaline with pale brownish veins.

Genitalia: Male plates elongate, rather narrow, apices broadly rounded. Styles strongly curved outwardly, apex bluntly pointed and bearing a pair of conspicuous spines. Aedeagus with the ventral portion forming a slightly enlarged apical head with a barbed spine at the base on either side; the dorsal portion is not quite as long as the ventral and is broadened at the apex to form a pointed protrusion at either side and a broad, slightly produced apical margin.

Holotype male collected at Covington, Tenn., June 18, 1915.

Holotype in the collection of the senior author.

Idiocerus apache var **juniperus** n. var.

Resembling *alternatus* in form and general appearance but with larger antennal discs and distinct genitalia. Length 4.5–5mm.

Face pale, lorae and genae with heavy brown longitudinal stripes. Upper portion of face with a large median dark area which extends across vertex as in *alternatus*. Vertex pale brown with a round black spot each side not far from eye and just above margin. Pronotum pale brown tinted with gray and with dark brown markings on anterior portion. Scutellum cream to pale brown, black spots in basal angles and a broad longitudinal white stripe on apical half. Elytra brownish subhyaline, veins dark brown interrupted by white portion at middle of clavus and apex of clavus. Male antennal discs black, elongate, ovate.

Genitalia: Female last ventral segment scarcely produced posteriorly, almost truncate Male plates elongate, rather narrow. Styles tapered, apical half rather slender, bearing a pair of spines near apex on dorsal portion. Ventral portion of aedeagus rather straight and slender with a pair of short barb like spines a short distance from apex. Dorsal portion of aedeagus broadened gradually then abruptly to form a broad apex which is slightly trilobate on apical margin and forms broad pointed lateral processes.

Holotype male taken at Mahomet, Ill., April 30, 1936, Frison and Ross. Allotype female from Golconda, Ill., June 22,1932 (Ross, Dozier and Park). Paratype males and females collected at Golconda, Ill., Urbana, Ill., April 6, 1900; Horseshoe Lake, Ill., July 11, 1935, by DeLong and Ross. Also Kampville, Ill., June 27, 1934, by DeLong and Ross.

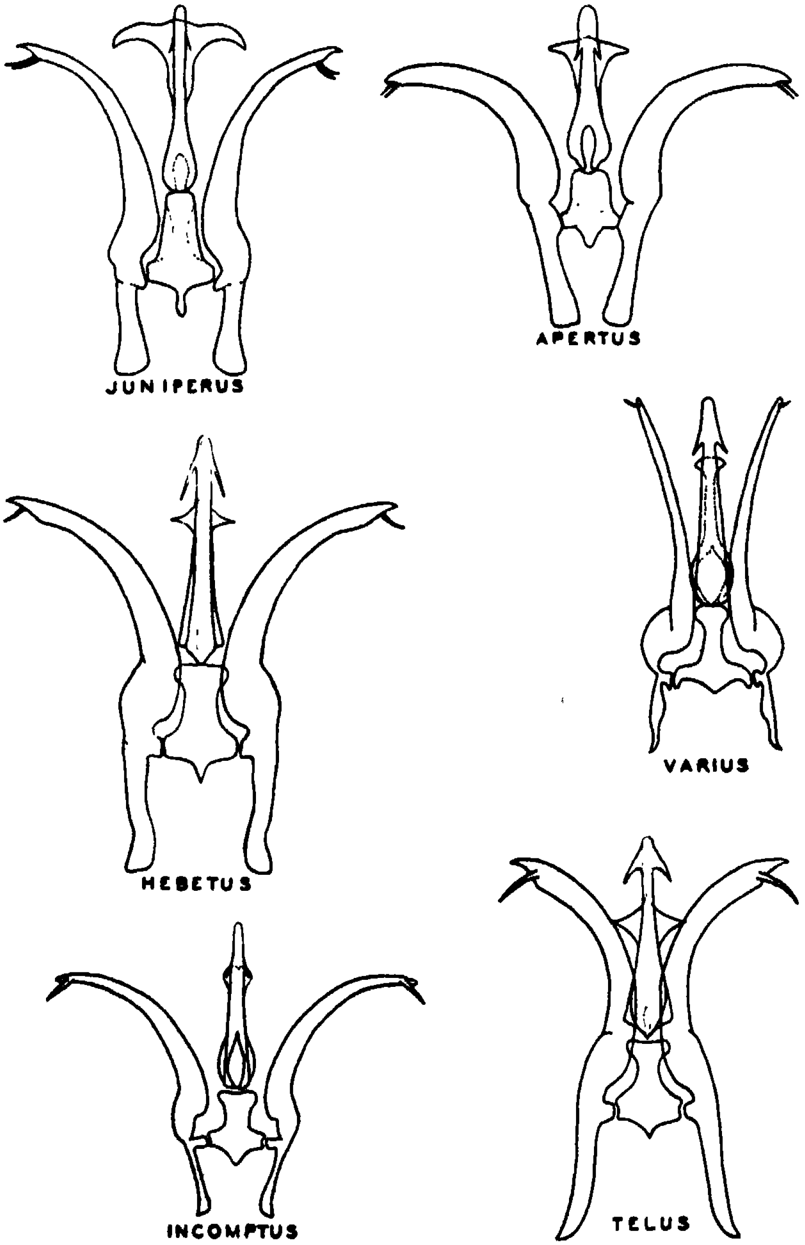
Holotype, allotype and paratypes in Illinois Natural History Survey Collection. Paratypes in senior author's collection.

This species was in manuscript before the recent publication of the species in the Ball collection. In view of its similarity to *apache* Ball and Parker, it is being placed as a variety of that species until further comparison can be made with the type.

Idiocerus varius n. sp.

Resembling *alternatus* in general coloration and apppearance but with distinct male genitalia, and large antennal discs. Length 5–5.5 mm.

Face marked as in *alternatus* with a large median dark area on upper portion extending across vertex. The vertex is marked with an elongated brown spot next each eye and a large round black spot not far from each eye just above margin. Pronotum brown with heavy dark markings. Scutellum pale brown with black spots in basal angles and a series of small connected black spots across middle. Elytra pale brownish subhyaline, veins dark brown interrupted by white veins at the middle of clavus and across elytron at apex of clavus. Male antennal discs broad, ovate and black.



JUNIPERUS

APERTUS

HEBETUS

VARIUS

INCOMPTUS

TELUS

Ventral views of aedeagi and styles of species of Idiocerus as labeled.

Genitalia: Female last ventral segment slightly roundedly produced posteriorly. Male plates elongate and narrow. Styles long and slender with a spine on each near apex. Ventral portion of aedeagus rather broad at base and tapered to form a rather narrowed head with a barb-like spine either side about one fourth the distance from apex. The dorsal portion of the aedeagus is broad at base, constricted on median portion and narrow to apex which is broadened to the width of the projecting spines on ventral portion. The apex is convexly rounded.

Holotype male collected at Paris, Tennessee, June 16, 1915 (DeLong). Allotype female from Dyersburg, Tenn., June 17, 1915 (DeLong). Male and female paratypes from Clarksville, Tenn., June and July, 1915; Cranberry Lake, N. Y., July 8, 1920 (R. J. Sim); Jemez Springs, N. Mex., June 16 and Sept. 15, 1919; Algonquin, Ill., July 1895 and July 1896; Golconda, Ill., June 22, 1932, by Ross, Dozier and Park; Castle Rock, Grand Detour, Ill., July 2, 1932, by Dozier and Mohr; Shawneetown, Ill., June 14, 1934 (DeLong and Ross); Karnak, Ill., June 14, 1934 (DeLong and Ross); Vienna, Ill., June 14, 1934 (DeLong and Ross); Rock Island, Ill., July 7, 1934 (DeLong and Ross); Jeff, Ill., June 12, 1934 (DeLong and Ross); Apple River Canyon State Park, Ill., July 11, 1934 (DeLong and Ross); July 16, 1936, by Mohr.

Holotype, allotype and paratypes in senior author's collection. Paratypes in Illinois Natural History Survey Collection.

Idiocerus hebetus n. sp.

Resembling lachrymalis in form and appearance but paler in color and male genitalia different. Length 6–7 mm.

Face pale, ocelli dark. A broken dark brown band on margin forming a dark spot next each eye, and a band produced upward on each end to include the round spot which occurs on *lachrymalis*. Pronotum cream to dark gray, median anterior portion pale brown. Scutellum white to cream, basal angles brown. A transverse line at middle brown. Elytra brownish subhyaline, darker on anterior half of clavus and apical portion. Male antennal discs narrow, elongate, black.

Genitalia: Male plates elongate and rather narrow. The styles are rather broad and only slightly tapered to near apex then pointed and bearing a prominent spine near apex. Ventral portion of aedeagus stout with a pair of rather long basally directed spines just before apex. Dorsal portion of aedeagus broader at base than ventral portion, narrowed, then broadened at apex to form a diamond shaped tip with a pointed apex and the lateral margins sharply angled.

Holotype male, allotype female and male and female paratypes collected from Aspen at Galena, Ill., June 28, 1935 and July 16, 1934, by DeLong and Ross.

Holotype male, allotype female and male and female paratypes in Illinois Natural History Survey Collection. Paratypes in senior author's collection.

This species can easily be distinguished from *lachrymalis* by the paler, more uniform, color; the smaller diamond shaped terminus of the dorsal aedeagus; and the single instead of the double spines at the apices of the styles.

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GEOLOGIC SECTION OF THE CHILLICOTHE TEST-CORE

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In the autumn of 1944 the Engineering Experiment Station of The Ohio State University put down a test boring southwest of Chillicothe, Ohio, for the purpose of obtaining a drill core for the determination of the petroleum content of the Ohio shale, foot by foot. Mr. L. C. Karrick, formerly of the U. S. Bureau of Mines, where he had had much experience in analyzing oil shale and coal, supervised the taking of the core and made the analyses for petroleum. A report on this study will be published by the Engineering Experiment Station at an early date.

The Experiment Station officials[1] allowed the writer to study the core and after the analyses were made, the unused parts were turned over to the Department of Geology. These include alternate ½-inch sections of the core through the Ohio shale and the complete core through the other formations.

The location of the test well is about three miles southwest of Chillicothe, on the south slope of Paint Creek Valley on the Hirsh Orchard Farm.[2] This is in the edge of the Appalachian Plateau where the surface is rugged and the local relief is 400 to 600 feet. A north-south cross section sketch of Paint Creek Valley is shown in Figure 1. The elevation of Paint Creek is here about 610 feet. The valley is broad with steep slopes which rise to a bench at 880 to 900 feet. Just below the edge of the bench the Berea sandstone commonly crops out in a cliff at the top of the steep valley side where it is undermined by the more rapid weathering and slumping away of the softer Bedford shale below. The lower slopes are at the level of the Ohio shale which is rarely exposed. The bench is at the horizon of the Sunbury shale and the overlying Cuyahoga shale which have been worn away more rapidly than the more resistant Berea sandstone below. The bench on the south is about one-fourth of a mile wide and beyond this the surface rises to a hill capped with a sandstone unit of the Logan formation at an elevation of 1260 feet.

The test boring is located near the edge of the bench at an elevation of about 880 feet. The total depth is 577 feet and the bottom of the well should have an

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[1] C. E. MacQuigg, Director; J. R. Shank, Assistant Director; T. H. Kerr, Supervisor of Fuels Research.

[2] From the Hirsch farm house on the south side of Paint Creek Road, a private farm road extends southwest for about one-fourth of a mile, up the slope along the course of a small run to the orchard located on a bench. The test boring is located about 50 yards northeast of where the farm road comes out of the head of the ravine onto the bench. The location of the test boring is in the southeast part of the Roxabell quadrangle, approximately 3300 feet S. 78° W. from the road fork which is just south of Paint Creek and one-eighth of a mile west of the east line of Huntington Township.

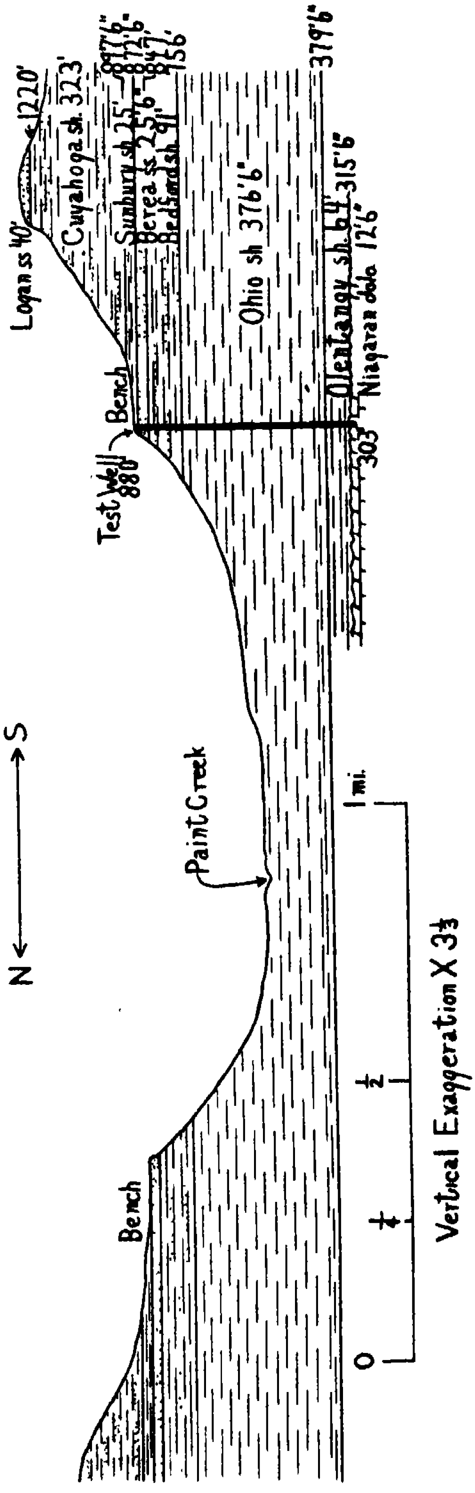

FIG. 1. North-south cross section of Paint Creek Valley about 3 miles southwest of Chillicothe, passing through the Chillicothe test well.

elevation of about 303 feet, at about 300 feet below the level of Paint Creek. The section of rock units penetrated is as follows:

Rock Unit	*Thickness*		*Depth to Base*	
	Ft.	*In.*	*Ft*	*In.*
Mantle rock	6	6	6	6
Sunbury shale	1	0	7	6
Berea sandstone	25	6	33	0
Bedford shale	91	0	124	0
Ohio shale	376	6	500	6
Olentangy shale	64	0	564	6
Niagaran dolomite	12	6	577	0

The first study of the core was very detailed in an attempt to separate every recognizable zone or unit. In this study 114 zones were separated and described In a later study this was reduced to 35 zones and again to a general section of 16 zones which is given below.

GEOLOGIC SECTION OF THE CHILLICOTHE TEST CORE

	Ft.	*In*
Mantle rock. 6 feet, 6 inches.		
1. Clay and fragments of yellow sandstone.	6	6
Sunbury shale. 1 foot.		
2. Black, fissile shale with *Lingula melia* and *Orbiculoidea herzeri*	1	0
Berea sandstone. 25 feet, 6 inches.		
3 Medium-grained, blue-gray sandstone with thin shaly partings	25	6
Bedford shale. 91 feet.		
4. Interbedded thin laminae and lenses of blue-gray sandstone and shale, with a few layers of sandstone 2 to 12 inches thick in the upper half and a 3-inch layer of sandstone at the base	22	6
5. Interbedded thin laminae and lenses of blue-gray sandstone and dark-blue shale in about equal amounts	20	0
6. Interbedded thin laminae and lenses of dark-blue shale and blue-gray sandstone with a few layers of sandstone 1 to 4 inches thick	26	6
7. Interbedded dark-blue and blue-gray shale with a few laminae and thin layer of sandstone in the upper half...	22	0
Ohio shale. 376 feet, 6 inches.		
8. Black shale with *Lingula*, fishplates, conodonts and macrospores.	25	6
9. Black to brownish-black shale with *Lingula*, fishplates and macrospores.	44	0
10. Black shale with a few layers of blue shale 2 to 6 inches thick	5	6
11. Brownish-black and blue-gray shale in interbedded thin layers and laminae.	21	0
12. Brownish-black shale with a few layers of blue-black and blue-gray shale and with a few gray, calcareous partings in the lower half	48	9
13. Brownish-black shale with thin layers and lenses of blue-black shale	168	6
14. Brownish-black shale with a few 2- to 6-inch layers of blue-gray shale	63	3
Olentangy shale. 64 feet.		
15. Blue-gray shale with layers of brownish-black, especially in basal 5 feet. *Lingula*, conodonts and macrospores in basal 2 feet	64	0
Niagaran dolomite. 12 feet, 6 inches.		
16. Bluish-gray to brownish-gray dolomite with quite variable texture	12	6

The highest bedrock present at the site of the test boring is the basal one foot of the Sunbury shale. Lying just below the mantle rock, this shale was greatly weathered and was not saved in the drill core. It was penetrated also in an excavation for a water-basin just beside the test boring and small fragments from this excavation showed the typical, black, fissile Sunbury shale, as well as the two characteristic fossils *Lingula melia* and *Orbiculoidea herzeri* which are so persistently present in central Ohio in the basal six inches of the Sunbury shale.

The upper five feet of the Berea sandstone of this core is much broken by weathering, yellow to buff in color, and contains thin partings and veins of ferruginous material. The lower half is argillaceous to shaly sandstone with an increasing number of partings and thin layers of shale downward. In fact the contact between the Berea and the Bedford must be somewhat arbitrarily chosen. There is no suggestion of a break between them.

The distinctive feature of the Bedford is the prominent and persistent alternation of thin layers and lenses of sandstone and shale within which are also a few definite layers of sandstone, increasing in thickness and number upward through the formation. In Franklin and Delaware counties most of the Bedford is soft clay shale with sandy laminae and thin layers in the upper 20 to 30 feet in some exposures. In the test-core section only the basal 10 to 15 feet is clay shale and all the rest contains abundant lenses and thin layers of sandstone The first appearance of arenaceous sediments came earlier in Ross County than in Franklin County. Further, the soft chocolate-brown clay shale that forms the middle part of the Bedford in Franklin and Delaware counties is not present in the test-core section. In the basal few feet of the Bedford of the test-core the fossils *Lingula* and *Orbiculoidea* were seen. They were very poorly preserved impressions, unidentifiable as to species. They were probably *Lingula meeki* and *Orbiculoidea newberryi* which are part of the larger fauna found in the basal two feet of the Bedford shale in Franklin County.[3] The contact of the Bedford with the Ohio shale below is definitely conformable.

The Ohio shale is black to brownish black with thin layers of blue-black to blue-gray shale. It is very uniform in color and texture and the slight differences upon which zones may be based in this test-core section could not be expected to hold laterally over large areas. In general the highest 75 feet is the blackest part and has the fewest bluish layers while the lowest 75 feet has the most bluish shale. That part between 75 and 150 feet below the top of the Ohio shale has a few thin, gray, calcareous partings.

Fossils found in the Ohio shale of this core include conodonts, minute fishplates, macrospores, and the brachiopod, *Lingula*. These fossils have not yet received the detailed microscopic study which most of this material requires and only general statements will be made concerning them.

The only invertebrate found is the brachiopod *Lingula*, of which there are two species: a smaller, elongate, subrectangular form about one-fourth of an inch long, apparently *Lingula spatulata*, and a larger, broader, more oval form about half an inch long. The smaller form was seen in the black shale at a number of levels in the upper 70 feet of the Ohio, at 91 feet below the top in blue shale, and at several levels at 4 to 12 feet above the base in mixed black and blue shale. The larger form was found at 83 and 91 feet below the top and at 18 feet above the base, all in blue-gray shale.

A number of conodonts were found in the upper 12 feet of the Ohio shale where the study was made with the binocular microscope. Below this level the microscope was not used and only a few conodonts were seen but it is probable that an examination with the microscope would reveal them throughout most of the formation. Several types of conodonts were recognized.

Small, black, glossy plates about one-eighth of an inch across, of several shapes and markings, were found at various levels in the Ohio shale. They resemble ganoid fish scales and apparently belong to the Rhadnichthids as figured by Branson from the Ohio shale of northern Ohio.[4]

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[3] Stauffer, C. R., Columbus Folio: U. S. Geol. Survey Folio 197, 1915, p. 7.

[4] Branson, E. B., Notes on the Ohio Shales and their Faunas: The University of Missouri Bulletin, Science Series, Vol. 2, No. 2, 1911, pp. 23-32.

The most abundant fossil of the Ohio shale is the minute, round, amber-colored macrospore, .25 to .5 millimeter in diameter known as ***Protosalvinia huronensis.*** They are common in the upper 25 feet of the formation and below this to about 200 feet they are present but uncommon. From 200 feet to the base at 376½ feet they are common and at some partings so abundant as to almost cover a bedding surface and give to it a brown color.

A very definite contact can be drawn between the Ohio and the Olentangy shales, but also it is a very definitely conformable contact. The lithologic difference between the two formations is only a matter of percentage of the kind of material making up both formations. The Ohio is dominantly black or brownish-black shale with layers of blue-black or blue-gray shale while the Olentangy is dominantly blue-gray shale with layers of brownish-black shale, which in this test-core section continue to the base of the Olentangy, for here the basal 3 feet is the blackest part of the formation. This section shows a close relation for the two formations, which should mean a close age relation. It supports the conclusions of Lamborn that the Olentangy shale of southern Ohio "is a basal phase of the Ohio shale and therefore Upper Devonian in age."[5]

Parts of the blue shale of the lower two-thirds of the Olentangy are slightly calcareous and the lower one-third contains small nodules or thin layers of calcareous material. Pyrite nodules were found at several horizons and also lenses and layers with much disseminated pyrite. Plant impressions or carbon films were seen at three horizons and a thin layer of grainy, fragmental material at two feet about the base yielded several types of conodonts, macrospores, and a few distorted specimens of a small Lingula.

The base of the Olentangy is firmly joined through a ½-inch, transition unit of grainy or fragmental material, to a crystalline dolomite below. The contact is uneven and it is definitely a disconformable contact. This dolomite was penetrated to a depth of 12 feet 6 inches, the bottom of the test boring. The dolomite is bluish-gray to brownish-gray and quite variable in texture. In part it is firmly crystalline and compact; in part of very rough texture with open spaces containing petroliferous staining; at places apparently brecciated as if crushed reef-material; the basal 4 feet is largely oolitic dolomite. No identifiable fossils were found in the dolomite but in the porous, crushed reef-rock material there are structures that suggest the compound coral ***Favosites*** and concentrically laminated masses suggesting stromatoporoids, all greatly altered. Although not absolutely conclusive, the evidence indicates that this dolomite is upper Niagaran, probably about the equivalent of the Peebles dolomite of Highland and Adams counties. That is, the Upper Devonian shale rests disconformably on Middle Silurian dolomite.

Passing southward from central Ohio the Olentangy-Ohio unit overlaps the outcrops of the Delaware and Columbus limestones in Pickaway County and thence southward to the Ohio River rests upon either the Greenfield or Niagaran dolomites. Further, in many of the sections of eastern Highland and Adams counties the Olentangy blue shale unit is missing and the Ohio black shale rests upon the Greenfield or Niagaran. This is readily explained by the interpretation that the Olentangy is merely a non-carbonaceous phase of the greater Ohio shale, a phase which was formed generally, but not everywhere, during the early part of the Ohio shale stage, being contemporaneous with black shale which was forming elsewhere.

The test-core section shows 64 feet of Olentangy shale between the Ohio shale and the dolomite. However, on the outcrop, 20 miles to the west near Greenfield, or 16 miles to the west-southwest near Bainbridge, the Ohio shale rests directly on the dolomites. This may mean that the deposition of the black sediments was at a later time and extended farther westward on the old erosion surface than did the blue sediments, or more probably it means that the sediments laid down farther west at Greenfield and Bainbridge contained enough carbonaceous material to make black shale while farther east at the test-core site, contemporaneous deposits without carbonaceous material resulted in blue shale. This accords with the usual interpretation of an eastward source for the Upper Devonian sediments, which were carried westward into a shallow, possibly stagnant, sea area where plant growth furnished the carbonaceous material for making black shale.

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[5] Lamborn, Raymond E., The Olentangy Shale in Southern Ohio: Jour. Geol., Vol. 35, 1937, p. 722.

The test-core section shows that the west edge of the Columbus-Delaware limestone unit which is overlapped in west central Pickaway County, must run southeast or southeast-by-east in order to pass east of the test-core site which is 16 miles east and about 20 miles south of where the limestones are overlapped. It also shows that the Silurian-Devonian disconformity, which along the outcrop in eastern Highland County is at approximately the contact of the Greenfield dolomite on the Niagaran dolomite does not rise eastward across the dip of the strata, but descends eastward with a somewhat greater dip than the strata in order that the Devonian shales rest on the Niagaran at the test-core site. The base of the Devonian shales, which on the outcrop south of Greenfield has an elevation of about 970 feet, drops to about 315 feet at the test-core site; a drop of about 655 feet in 20 miles to the east, or about 33 feet per mile, which is approximately the regional dip of this part of the state. Assuming that the old erosion surface which truncates the Silurian dolomites was approximately horizontal and that the Upper Devonian shales were laid essentially horizontal, it appears that all the regional dip was produced in post Devonian time.

WAYNESBURG COAL IN HARRISON AND NORTHERN BELMONT COUNTIES, OHIO, AND REVISION OF DUNKARD (PERMIAN) BOUNDARY

GEORGE W. WHITE,
Geological Survey of Ohio

INTRODUCTION

In a study of the Monongahela formation in Harrison County and northern Belmont County it was discovered that the Waynesburg coal is more extensive than formerly known. As the Waynesburg coal is of minable thickness at many places, a map and brief description of the coal may be of value. In addition, as the top of the Waynesburg coal is the dividing plane between the Pennsylvanian and Permian systems of strata, this study provides a modification of the geologic map of the base of the Dunkard (Permian) rocks,[1] especially in Harrison County where no Permian was shown. The map, Plate I, includes parts of the Flushing and St. Clairsville quadrangles of the U. S. Geological Survey, which have been used as a base. The outcrop of the Waynesburg coal is shown by a black line, the measured elevations being indicated. The area shown in green is the area underlain by the coal and that where the surface rocks are Dunkard (Permian) in age. The location of this area in Ohio is shown on an index map, Fig. 1.

The writer's field study in Harrison County and in Belmont County north of the National Road, is a northward extension of the work of Dr. Wilber Stout on the Monongahela formation in the "main field" to the south. Dr. Stout's monographic report in the files of the Geological Survey is being prepared for publication and a discussion of the Monongahela stratigraphy of the area north of the National Road will be added to his report. On Plate I the outcrop line and sections shown south of the National Road and in southeast Colerain Township are from Stout's data. The report and maps of Lamborn[2] have been used for that part of Jefferson County shown on Plate I. The areal reports of Mitchell[3] on Richland Township and of Eberle[4] on Flushing and Wheeling townships were useful and E27 and E21 of Plate I, shown as 161 and 173, respectively, on Plate II are after Eberle.

STRATIGRAPHIC POSITION

The top of the Waynesburg coal is the boundary between the Monongahela formation, of Pennsylvanian age, and the overlying Washington formation of the Dunkard Series of Permian age.[5] The base of the Monongahela formation is the base of the Pittsburgh coal. Sections of the Monongahela formation have been given by Stout[6] and the section at Blaine Hill on the National Highway in N.E.

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[1] Stauffer, C. R., and Schroyer, C. R., "The Dunkard Series of Ohio," *Geol. Survey Ohio Bull. 22*, map, p. 12, 1920.

[2] Lamborn, R. E., "Geology of Jefferson County," *Geol. Survey Ohio Bull. 35*, 1930.

[3] Mitchell, R. H., "The Geology of Richland Township, Belmont County, Ohio," unpublished thesis, Ohio State Univ., 1929.

[4] Eberle, R. F., "The Geology of Wheeling and Flushing Townships, Belmont County, Ohio," unpublished thesis, Ohio State Univ., 1936.

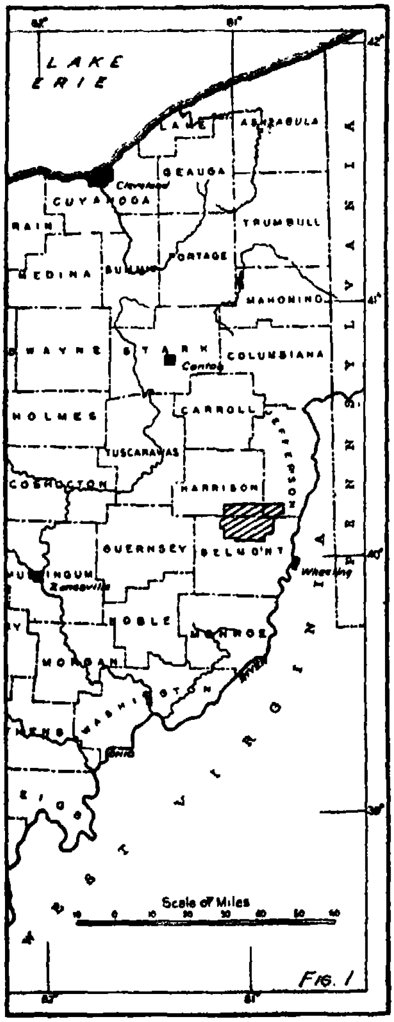
[5] White, I. C., "Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio, and West Virginia," *U. S. Geol. Survey Bull. 65*, p. 41, 1891.

Stauffer and Schroyer, *op. cit.*, pp. 9–11.

[6] Stout, W., "The Monongahela Series in Eastern Ohio," *Proc. W. Va. Acad. Sci.*, Vol. 3, pp. 118–133, 1930.

Idem, "Generalized Section of the Coal-Bearing Rocks of Ohio," *Geol. Survey Ohio Inf. Circ. No. 2*, 1939.

Sect. 21, Richland Township, Belmont County, has been described by the writer[7] and is shown (in part) graphically in 187, Fig. 2. According to Stout[8] the top of the Waynesburg coal in Belmont County (not including measurements from the central northern and northwestern parts) lies on the average 253 feet above the base of the Pittsburgh coal, 162 feet above the Meigs Creek coal, 103 feet above the Fulton green shale, and 50 feet above the Uniontown coal. At the Blaine Hill section (Fig. 2), these intervals are smaller but not significantly so, being 240½,



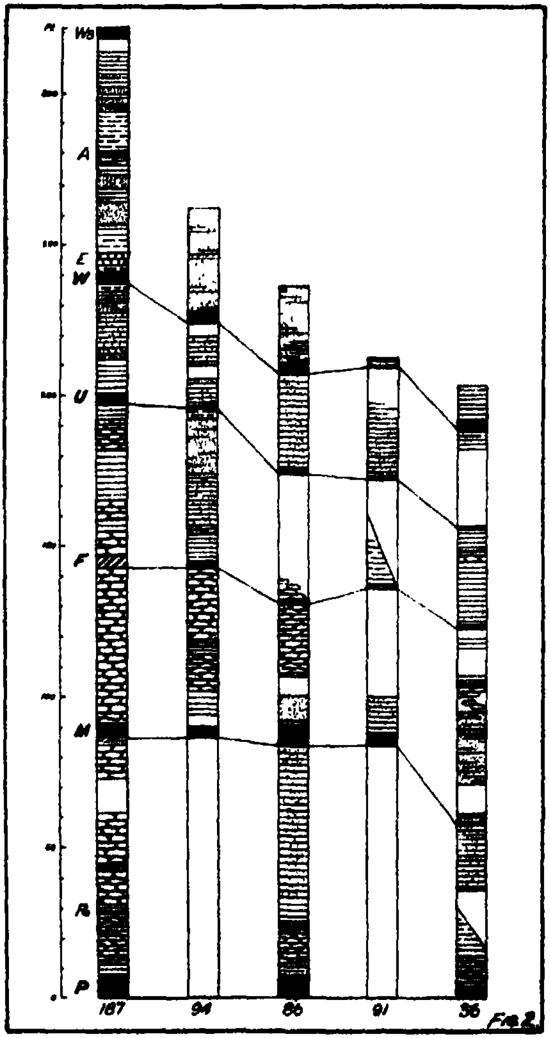


FIG. 1. Map of eastern Ohio showing location of area.

FIG. 2. Columnar sections of strata. Locations of sections shown on Plate II and given in text. Key: P, Pittsburgh coal; Po, Pomeroy coal; M, Meigs Creek coal; F, Fulton green shale; U, Uniontown coal; W, Waynesburg coal; E, Elm Grove limestone; A, Waynesburg "A" coal; Ws, Washington coal.

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[7] White, G. W., "Upper Pennsylvanian and Lower Permian Rock Section at Blaine Hill, Belmont County, Ohio," *Ohio Jour. Sci.*, Vol. 45, pp. 173–179, 1945.

[8] Stout, "Monongahela Series. . . . ," *op. cit.*, p. 121.

154½, 98, and 44½ feet respectively. Northward, in Colerain Township, the intervals are essentially similar to those at Blaine Hill. Farther northward, in Sect. 11, Mt. Pleasant Township, Jefferson County,[9] the Waynesburg is 224 feet above the Pittsburgh and 142 feet above the Meigs Creek. To the northwest of Blaine Hill, in southeastern Harrison County, in W. Sect. 4 and N. Sect. 11, Short Creek Township (94 and 86, Plate I, and Fig. 2) the intervals are reduced. In W. Sect. 28 of the same township the Meigs Creek-Waynesburg interval is similar (91, Fig. 2, three-eighths mile south of 179 of Plate I). Farther west, in N.E. Sect. 17, Athens Township, Harrison County (36, Plate I, and Fig. 2), the intervals are still less. Here the Waynesburg lies closer to the Pittsburgh coal than does the Uniontown at Blaine Hill. An analysis of Fig. 2 shows that the reduction in the Waynesburg-Pittsburgh interval from Blaine Hill northward is due solely to a lessening of the Waynesburg-Meigs Creek interval, and that the further reduction westward is due to a decrease of the Meigs Creek-Pittsburgh interval.

ELEVATION AND STRUCTURE

The Waynesburg coal outcrops at elevations ranging from 1,290 feet in Sect. 17, Athens Township, Harrison County, to 1,000 feet in Sect. 10, Colerain Township, Belmont County (Plate I). The general direction of dip is east-southeast, with local variations. The dip is only a few feet per mile in the northwestern part of the area but may reach 30 feet or more per mile in the southwestern part. As shown on the map, the member is found only in small areas on hill and ridge tops in the western and northern parts of the region, but is much more extensive and nearer the valley bottoms in the southeastern part.

THICKNESS AND CHARACTER

Within the region under discussion the Waynesburg coal varies in thickness from a few inches to almost 5 feet. Over considerable areas the thickness is 3 to 3½ feet. Plate II shows the thickness of the coal at each place designated by the corresponding stratigraphic section number of the map, Plate I.

The Waynesburg coal is a bright, banded, bituminous coal. This coal almost everywhere has one or more partings, which may be either clay shale or carbonaceous shale. The lower half of the bed usually, but not always, has more of these partings than the upper half. Partings are most numerous in Short Creek Township, Harrison County. In Flushing and Kirkwood townships, Belmont County, the upper part of the bed consists of carbonaceous shale rather than coal.

The Waynesburg coal in Mt. Pleasant Township, Jefferson County, has been described by Lamborn[10] as weathered blossom from 2 ft. 6 in. to 2 ft. 10 in. in thickness. It is probable that under cover the Waynesburg coal in parts of this township is 3 feet or more in thickness.

A sample of Waynesburg coal[11] was taken in 1927 by the writer and P. E. Fitzgerald from the local mine of A. B. Shields, S.W. ¼ Sect. 36, Colerain Township, Belmont County (B34, Plates I and II). Analysis by D. J. Demorest:

		Ft.	In.
Sandstone, massive.			
Sandstone, shaly		0	3
Coal, good, sampled	*Waynesburg*	3	1
Shale, dark, rejected		0	1½
Coal, good, sampled		0	9½
Shale, with pyrite bands, rejected		0	⅜
Coal, bony, rejected		0	2
Shale, gray, soft.			

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[9] Lamborn, *op. cit.*, p. 33.

[10] Lamborn, *op. cit.*, pp. 252–253.

[11] Bownocker, J. A., and Dean, E. S., "Analyses of Coals of Ohio," *Geol. Survey Ohio Bull. 34*, p. 277, 1929.

Proximate analysis

	As received	Moisture free
Moisture	5.27	0.00
Volatile matter	37.42	39.50
Fixed carbon	42.61	44.98
Ash	14.70	15.52
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	64.45	68.04
Hydrogen	4.97	4.62
Oxygen	12.25	7.99
Nitrogen	1.44	1.52
Sulphur	2.19	2.31
Ash	14.70	15.52
	100.00	100.00

Air drying loss 2.3 per cent.

		As received	Moisture free
Heating value	Calories	6,434	6,792
	B. t. u.	11,581	12,225
Fusion of ash	Incipient	2,583° F.	
	Complete	2,635° F.	

Ten other analyses of the Waynesburg coal[12] from Belmont County east and south of the region here discussed show this coal (as received) ranging from 1.78 to 5.72 moisture; 35.32 to 40.07 V. M.; 39.70 to 45.89 F. C.; 13.07 to 16.87 ash; 1.75 to 4.91 S.; and 11,000 to 12,020 B.t.u. From the analysis from Colerain Township the coal is high volatile bituminous B but close to the A range,[13] into which range falls at least one sample of Waynesburg coal,[14] that from central Sect. 36, Richland Township, Belmont County, (1 mile S.E. of S209, Plate I), just south of the region here discussed.

The roof of the Waynesburg coal is at most places shale, often sandy and ferruginous. In Harrison County the shale becomes more sandy upward and a few feet above the coal may pass into shaly sandstone. In much of Belmont County the roof material is shale, grading upward to shaly sandstone. In the eastern margin of the region from one to several feet of clay shale overlies the coal, the shale being overlain by the dense Elm Grove limestone,[15] which, however, is replaced by sandstone at places. On the whole, roof conditions for mining may be considered fair to good, except where the coal is under shallow covering and weathering has affected the roof strata.

The material beneath the coal is gray clay shale, at places having the appearance of a very impure fire clay. In thickness the clay shale varies from a few inches to several feet, 2 feet being about average. Below the clay shale is shale of coarser grain. Unless abnormally wet conditions obtained the material beneath Waynesburg coal should satisfactorily support mine props and tracks.

USE AND RESERVES

In Harrison County the Waynesburg coal has been mined in a small way on the farm of F. M. Price, W. Sect. 11, Short Creek Township (88, Plates I and II). The coal is reported to burn well in stoves, with considerable ash but without clinkers. The coal was mined many years ago in a small way on the north edge of Harrisville but the mine has long since been abandoned. No other use of the coal in Harrison County is known.

In Belmont County the coal has been mined in a few small operations for household use, all now inactive, in Colerain and Richland townships, and in other townships east and south of the region here discussed. With the exception of the removal of a very small amount of coal from these minor operations, the entire area of the Waynesburg coal shown in Plate I is part of the coal reserve of Ohio.

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[12] *Ibid.*, pp. 277-283, 327-328.

[13] Fieldner, A. C., and others, "Classification Chart of Typical Coals of the United States," *U. S. Bur. Mines Rept. Inv. 3996R*, pp. 3, 5, 1939.

[14] Bownocker and Dean, *op. cit.*, pp. 277-278.

[15] White, G. W., *op. cit.*, p. 176.

PRODUCTION OF BALANCED SQUARE WAVES FOR ELECTRONIC STIMULATION

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INTRODUCTION

It is generally recognized that integrated organisms have definite reactions to electronic currents. Animal reactions to electrical stimulation are related to the strength of the stimulus (voltage); the quantity of the stimulus (amperage), and the nature of the stimulus (wave form). Instantaneously interrupted electron currents have proven to be quantitatively applicable to behavior studies. The spaced sudden shock type of Hill (1934) or the controlled interruptions of direct current described by Ritchie (1944) are the conventional methods of current application for this type of work. The several devices which we present below produce a balanced square wave, i e., an instantaneous interchange of cathode and anode at a controlled tempo. With such electrical mechanisms it is possible through synchronization of movement with wave form to quantitatively interpret reactions to electron stimulation.

In the biological laboratory this instantaneous interchange may be accomplished by a double pole double throw (dpdt) hand switch. In a physics laboratory an electronic switch or square wave generator is used to accomplish the same result. With these types of mechanisms it is possible to effect an electrical stimulation, the electro-chemical results of which are equal and opposite.

METHODS OF PRODUCTION

With the common dpdt switch, the interchange is made at as slow a tempo as may be desired. Although we have the human element herein, it would be negligible in frequencies of one interchange every several seconds. This method of production is shown in Fig. 1. It was determined, however, that frequencies beyond the accuracy range of the dpdt switch were required in the behavior laboratory.

To produce controlled frequencies accurately between .25 and 5 cycles per second, a special mechanism was designed. This consists of a variable speed motor with an external commutator which excites a dpdt electric relay. With such a device voltage as well as frequency may be varied. See Fig. 2 for details.

To produce controlled frequencies of a higher range (5 to 100,000 cycles per second) a variable square wave generator is used. With such a device it is also possible to accurately control both frequency and output voltage. An oscillograph when employed in the circuit provides a visual check on wave form, frequency and voltage. See Fig. 3 for details.

INTERPRETATION

The variable speed motor with an external commutator activating a dpdt relay produces an instantaneous interchange with satisfactory accuracy at lower frequencies. The calculation of frequency output from this mechanism is based upon the revolutions per minute of the commutator. At low speeds this can be reasonably determined by a stop watch, higher speeds requiring either a RPM meter or an oscillograph for visual observation.

As previously stated, a variable square wave generator provides with accuracy variable frequencies in the higher range. A relatively accurate check of the

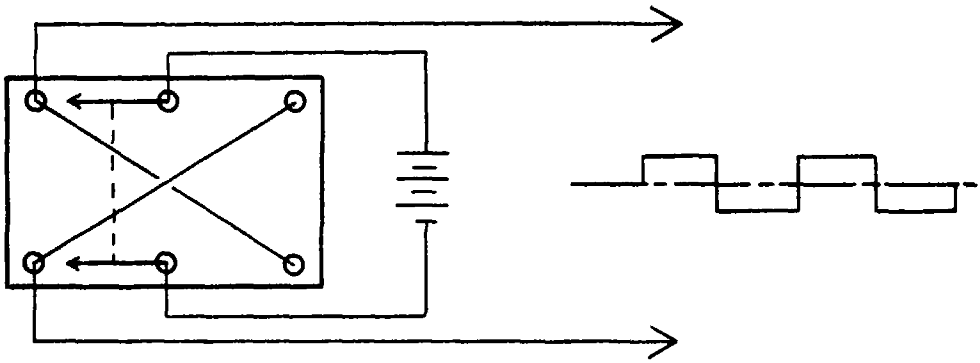

FIG. 1

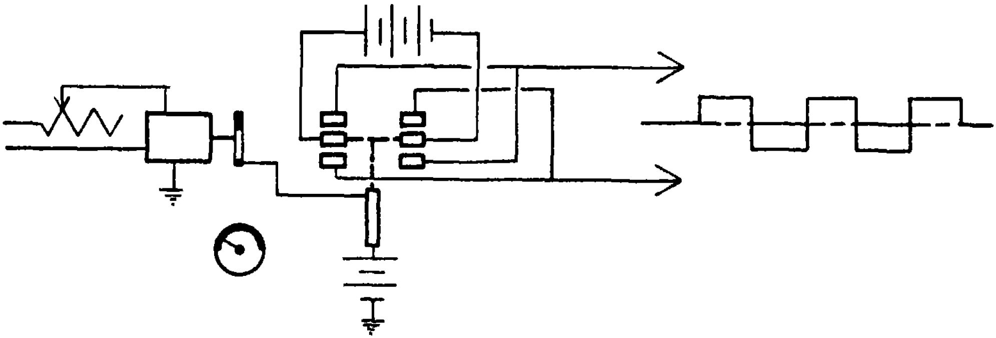

FIG. 2

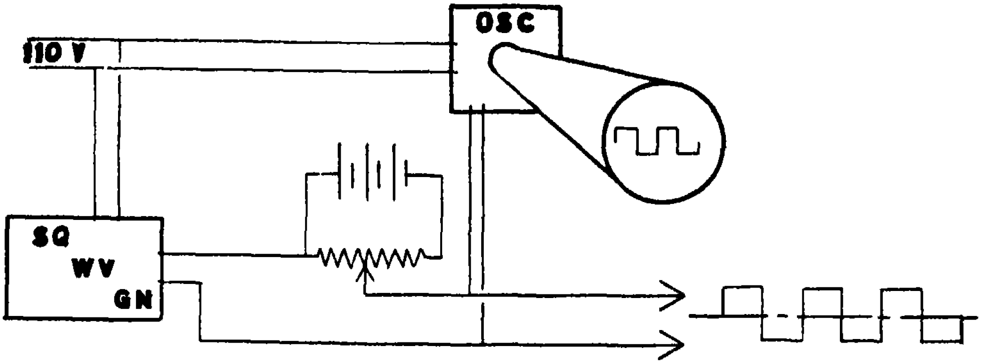

FIG. 3

FIG. 1. Hand operated double pole double throw switch.

FIG. 2. Variable speed motor with external commutator exciting a double pole double throw electric relay.

FIG. 3. Variable square wave generator, with balancing batteries and oscillograph.

calibrated output may be made through the use of an oscillograph after synchronization with a known frequency. Utilization of the direct deflection plates of the oscillograph makes it possible to visually determine voltage reference level and output. The reference level may be set to ground through the use of balancing batteries (Fig. 3).

The oscillograph employed in the above circuit has its sweep synchronized to a known frequency. Interpretation of any higher harmonic is then possible by direct count of cycles shown on the screen of the cathode ray tube.

APPLICATION

The above described apparatus provides a means of applying electrical stimulation of known frequencies. Interesting results were obtained using Protozoa as test organisms and will be reported in an early issue of this Journal.

REFERENCES

Hill, A. V. 1934. Repetitive stimulation by commutator and condenser. Jour. Physiol , 82: 4.

Ritchie, A. E. 1944. A simple variable "square wave" stimulator by biological work. Jour. Sci. Instruments, 21: 4.

Genetics is a Mathematical Science

The early work of Hardy, Weinberg and Jennings laid the groundwork for clarifying the statistical implications of the theory of the gene. On this basis has been built a formidable superstructure of mathematical analysis of many types of genetical problems. Among the important problems analyzed in this way are those associated with systems of mating, particularly in agriculture, with evolution, and with human genetics. Dr. Hogben, a noted elucidator of mathematical theory, attempts in this book to make clear the statistical and mathematical ideology underlying modern genetics. It appears to this reviewer that Hogben has been less successful in this attempt than in some of his previous books on other phases of arithmetic. The book is not easy reading, in spite of the essential simplicity of the material covered. Frequently the reader is more muddled at the end of a chapter than he was at the start. Nevertheless there is much of value to be gleaned from the book by careful winnowing. Of particular importance are the chapters on mutation and selection pressures, and on non-assortative and assortative mating. Here the direct connection with genetics and evolution is more evident, and the reader's interest is more steadily maintained. The book is recommended as a reference work for those who are satistically minded. Exercises are provided at the ends of the various sections, and the answers to the exercises are also made available. Two appendices discuss significance tests for Mendelian ratios, and maximum likelihood methods of analyzing various genetic experiments. An excellent index completes the volume.—*L. H. Snyder.*

An Introduction to Mathematical Genetics, by Lancelot Hogben. xii+260 pp. New York, W. W. Norton and Co., Inc. 1946.

WHAT IS EMOTION?

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Emotion is one of those terms we use so familiarly that we seldom ask what they really mean. Let the reader try to compose a definition which would help anyone to identify the phenomena referred to. Let him see how little help is to be found in a dictionary.

The difficulty is not entirely due to ignorance. We now have an astonishing welter of detailed fact about emotional behavior, particularly in childhood and in many abnormal conditions. When, however, we try to organize these facts in a coherent pattern, we run into many perplexities. Indeed some psychologists believe that the kinds of behavior traditionally called emotional are so diverse that they cannot be usefully treated together. This article is an attempt, however, to classify these behaviors in a meaningful way and for the intelligent layman.

A useful treatment of the subject must begin, however, by changing the form of question usually asked. The older psychology began by asking "what is in our consciousness or mind during emotion?" This approach has on the whole proved rather sterile, particularly in child psychology. Contemporary scientific psychology no longer asks about the "contents of consciousness" nor even about "what's in your mind" (though the Freudian movement unfortunately often uses such a phraseology). Instead, it asks what people do and why and how. We must ask, then, what it is that we *do* when we emote.

The verb, to emote, finds no place as yet in the dictionary. Such a term is, however, sadly needed, not only for its convenience but in recognition of the shift in emphasis in psychology from a study of "mental contents" (represented by nouns) to a study of activities (best represented by verbs). When old terms fail to express our meaning, we have two choices: to put forward a neologism constructed according to etymological "rules," or to hunt for an acceptable current expression. The fact that "emote" is already in wide use as slang and is immediately understood indicates that it is in accord with the genius of the language. The step from slang to propriety should therefore be easy—and much preferable to the invention of a term which would need not only defense but explanation.

THE COMPONENTS OF EMOTING

Emoting, it is sufficiently obvious, is a complex tangle of personal activities. Our initial task is therefore to seek the component parts of this complex behavior.

1. The first thing we do when we emote—at least, usually—is to perceive or imagine the emotive situation or object. This is so obvious that it is usually ignored—to the serious damage of our thinking about the subject. Perhaps this is because in emotion we often do not specifically attend to the object nor think about it; and sometimes we do not even realize that it is this object with which our emoting is connected. But awareness of the emotive situation does happen.

2. Then we do something to *alter* or *control* the external circumstances which constitute the emotive situation. If we consider an object fearsome, we flee from it or endeavor in some other way to rid ourselves of it. If we are angry we no less obviously endeavor to alter the object or situation by "attacking" it. If our feeling is of the pleasant variety our effort may be rather to maintain and cherish than to remove the object of emoting. Yet even here we also "alter" it—as when we eat a luscious tidbit or pet a cat or dog. In all cases we make, or at least tend to make, an objective or *external adaptation* or *adjustment*, an adjustment directed toward the emotive situation or some object in it.

In the infant these movements of external adaptation are very confused and chaotic, and differ little from one sort of situation to another. Even so, there is activity directed outward upon the environment, as when an obnoxious stimulus leads to squirming or thrashing about. As the child grows older, the action tends to becomes less "all-over," more precisely adjusted to the kind of situation, more differentiated and adaptive. But always there is a great deal of ill-coordinated movement in emoting. These external adjustments are accomplished by tugging at our bones with the so-called striped muscles. Many psychologists have therefore followed the lead of the anatomist and physiologist in calling them skeletal responses; since, however, there are other skeletal responses with a somewhat different function, the usage is rather unfortunate as far as psychology is concerned.

Not to recognize these outwardly directed actions as an *essential* part of emotional behavior is to lose an important clue to understanding the problem. Particularly is this true in childhood. Unfortunately, such recognition is not always forthcoming. Laymen and psychologists alike often speak of these responses as if they were something tacked on, a sort of result or sequel of emotion. As we shall see later, this leaves us with an incomplete picture.

3. The ancients localized the several emotions in the internal organs: the heart was the organ of love, the spleen of anger, the bowels of pity and yearning, and so on. They were partly correct. What we may call the "Department of the Interior" must indeed be heard from. In every emoting some at least of our glands (of which we now hear so much) are directly involved; and, since the glands are intimately interconnected, it is probable that nearly all of them are active in some way in each case.

Then, too, the muscles of the genito-urinary tract, and those lining the walls of the digestive tract—"smooth" muscles the anatomist calls them—are involved in characteristic ways. The diaphragm and breathing are affected, and there are striking changes in the circulation of the blood in response to varied heart action and to changes in the tension of the arterial walls in different parts of the body. Even when emoting rather mildly we are apt to be considerably "stirred up inside."

Psychologically, these responses may be considered as a sort of *internal adaptation* to the emotive situation just as the skeletal responses constitute an external adjustment. There is much controversy, however, as to whether these internal responses should be considered adjustive or helpful. In some cases they seem to prepare the individual for external adjustments to come. In other cases, however, the internal responses, especially if violent, tend to interfere with and disrupt the external adjustment. Our own use of the term adaptation is not intended to prejudge the issue as to whether the internal response is helpful. It merely calls attention to the fact that these internal reactions are changes in the individual with reference to the emotive situation, and hence are a sort of adaptation to it, though possibly not a good one. Nearly all of these reactions are controlled by the autonomic nervous system, and some writers therefore call this aspect of emoting "autonomic response." But there are other autonomic activities, which, so far as we know, play no part in emoting, so the usage is a little dubious. The term "visceral response," which is even more common, is open to the same objection. Moreover, arterial changes are not strictly visceral. We prefer the term "internal responses."

4. For the next class of responses which we make when emoting, we may follow an old tradition in speaking of the "*expressive movements*." To this class belong scowling, smiling, tightening the jaw, clenching teeth or fist, gesturing, perspiring, blushing, blanching, gooseflesh, and various tense and relaxed postures. Here also belong verbal interjections: groans, sighs, exclamations of surprise, pain, anger, or horror; and cries of pleasure and joy as well.

All these are usually called expressions of emotion as if the emotion were one thing and the expressions another. But these responses are truly *part* of what we do when emoting, not something distinct or added on. Indeed no emotion is quite complete without them. Try, for example, to enjoy a beautiful scene or great music without making any such reactions. Or note how great fear is lessened if there are few "expressions" of fear.

Darwin believed that all these "expressions" were vestiges of earlier adaptive responses—we bare the teeth in anger, he thought, because we are getting ready literally to bite. Today few accept his view except in a very general form. These responses serve our adaptation to the emotive situation in a quite different way. Essentially they are a sort of *emotional language* and work upon other persons in the situation. The bared teeth may frighten off the anger-arousing person, the cry of pain may bring help or enlist sympathy. The expressive reactions are primarily social adjustments.

5. Similarly social are certain forms of *verbal activity* which form part of emotional behavior. We threaten, cajole, plead, banter, verbally caress, coax, command, and otherwise attempt by our words to influence the persons who form part of our emotional situation. Such verbal conduct while very similar to the interjections of section 4, is not so primitive as other parts of emotion and often seems not to integrate or "tie in" closely with the rest. For this reason it seems better to make a distinct class for it. No catalog of the forms of emotional activity would, however, be complete without listing these language responses.

6. Lastly, we may distinguish an important but little regarded group of responses. This is the verbal response of naming the emotional behavior. This naming is not always audible; we say to ourselves: "Oh, I'm so happy," "Angry enough to bite nails," "Down-in-the-mouth." Infants and animals of course have no such reactions and they are often lacking in children or adults. Indeed sometimes we cannot name our feelings at all, somewhat to our discomfiture. But what we may call the "*secondary naming*" is a genuine part of many emotional behaviors.

Readers with some acquaintance with physiology and anatomy may be distressed by the proposed classification of emotional behaviors. These sciences recognize three broad classes of reaction: those of the striped or skeletal muscles, those of the smooth muscles, and those of the glands of internal or external secretion. Our classification obviously cuts clear across this pattern. The external adjustment responses of our Class 2 are skeletal, but do not include all of the skeletal movements. The internal adjustment of Class 3 includes smooth muscle responses and both types of glandular responses; but again it is very doubtful that all such responses are involved in emoting. As for the expressive movements (Class 4), here is, *physiologically* considered, confusion for sure: skeletal responses (as in clenching the fist or scowling), smooth muscles (as in blushing), and glands of external secretion (as in dry mouth, weeping, perspiring). Some of these reactions belong to the cerebro-spinal system, some to the autonomic. Vocalizing behavior, which is skeletal for the physiologist, is found in no less than three of our classes. As for our first class, the perceiving of the emotive situation, no one really knows very much as to what, in physiological terms, is going on beyond the activity of the sense organs immediately involved.

Actually such a difference between the way facts are classified in two sciences should occasion neither surprise nor concern. Every science necessarily has its own structure. The *facts* discovered in one science must be accepted by all other sciences; but the classification of the facts depends upon what one is trying to do. Indeed, the importation into a science of the concepts of another is apt to be dangerous. The unity of science is the unity of *common facts* and a *common logic*, not of a common conceptual framework.

THE DIFFERENCE BETWEEN EMOTING AND OTHER ACTIONS

Here, then, are six ways of acting which in their totality constitute emoting. But what other acts do *not* show exactly the same classes of behavior? When, for example, one calmly drives an auto through a crowded street, copies a drawing of a gear wheel, or studies how to persuade the boss to give one a raise, one is not ordinarily thought of as acting emotionally, yet each of the six classes of action listed above is involved (or at least may be) in these non-emotional acts.

We could, at this point, fall back on the truism that we probably never act at all without emoting a little bit, but that would be something of an evasion. It is a fair demand that we differentiate between what we ordinarily call emotional and non-emotional action, and our analysis leaves the way open for just that differentiation. ***Emoting is a complex and extended way of acting in which behavior is dominated by or integrated around the activities of internal adjustment.***

Indeed the internal or so-called visceral responses often dominate the stage so thoroughly that we tend to over-estimate their role, even to identify emoting with just that one aspect. This is a mistake. The internal component is truly a *necessary* part of any behavior we call emotional and the other parts are organized around it; but it is never the whole act.

In the first place, if we do not perceive or imagine the stimulating circumstances, the whole drama fails to unroll. The "uncaused" fears sometimes found in the insane are probably no exception, since the patient is probably reacting, directly or indirectly, to some obscure imaginary situation which he cannot name or describe. Moreover, the end of emoting comes, not when the situation actually changes, but when we perceive it in a different way.

A second difficulty is that the internal responses of different emotions seem so extraordinarily alike. Neither to introspection nor to objective measurement does the internal reaction of fear differ materially from that of anger; and the more we know about the two ways of emoting the more alike the internal responses seem to be. As far as internal adjustment goes, we seem to have but two kinds of emoting: a plus or favoring kind and a minus or rejecting kind. Now to reduce all emotion to just two certainly cannot do justice to the variety of feelings which mankind has so long celebrated in song and story; and the subtle variations are not something just tacked on but an intrinsic part of the whole pattern. To identify emoting with just its central core of internal responses is to miss the factors which differentiate one feeling from another.

Finally, to identify emoting with the internal response is to imply that the latter has significance all by itself. That is not the case. The internal reaction must be seen in relation with the other components if "emotion" is to make sense. A merely internal adaptation of a person without at least a tendency toward external adjustment—be it physical or social—is almost unthinkable, and if it were thinkable would be most injudicious. However central the internal adjustment is in emoting, we must not ignore the other components with which it is inseparably joined.

EMOTING AS AN INTEGRATION

Some of you may be inclined at this point to object to the analysis as incomplete. It is like *Hamlet* without the Prince of Denmark. What, you may ask, about the feelings, the emotions themselves? Are not all these bodily activities which we have been talking about merely the accompaniments of the emotion? No one questions, you add, that all these physiological functions of gland and muscle are somehow involved in emotion, but to say they *are* emotion is to leave out the mental or spiritual aspect which is the most important of all.

Well, it is not possible to be dogmatic here. All one can do is to ask that the objection be clearly stated. Just where *is* the feeling we have so far omitted?

Or rather, how do we do it? For it is to be remembered that our question is, What do we *do* when we emote? To say that we run, that we blush, that we exclaim, that we get all stirred up in what the Scotch call our "insides"—that is intelligible and demonstrable. Is there anything else that we do? If so, what is it?

Note that this way of looking at the matter does not deny at all that there is a specific way of acting called fearing or loving or being anxious or disgusted. It just says that fearing is the ***sum-total***, or better, the ***integration*** of the things we demonstrably do when we fear. Joy, likewise, is just the particular combination of things done, or rather of "doings." A particular emoting, that is to say, is not something over and above the ways of acting we have listed; these in their totality ***are*** the emoting. Fear and anger and disgust and joy and love and happiness are simply ***you in action*** in as many different ways.

To say this, moreover, is not to deny to emoting spiritual value. On the contrary, to think of anger or fear or joy as ***particular ways of living*** seems a much richer concept than to think of them as some sort of "mental content" locked up in each individual's mind and inaccessible to anyone else save indirectly. Joy remains joy no matter how it is analyzed. Even though it be shown that what we do when we are happy is to integrate certain adaptive big-muscle movements, certain internal reactions, and certain verbal activities, happiness remains the chief, if not the only, source of human values.

We do not wish, however, to close the door to any facts. The foregoing analysis may not be complete; the way is open to any addition of a demonstrable mode of acting which takes place when we emote. The virtue of our analysis consists chiefly in that it provides us with convenient pegs whereon to hang facts of considerable value to those who must deal with the emotional problems of themselves and others.

Insect Microbiology

This book treats the various associations and relationships existing between all types of microbes and insects (including ticks and mites) from a biologic viewpoint. It is essentially a compilation of widely scattered data on this important subject but much of these data have not been sufficiently studied to present adequate bases for discussions relating to the biologic relationships involved. By the bringing together of this information into one volume and pointing out places where insufficient knowledge is lacking, advances in this phase of science should now be more rapid. It is through researches of this type that all branches of science are ultimately benefited. The writer is to be commended for this contribution which should be a valuable aid to the teachers and research workers in biological sciences but especially the medical entomologist, pathologist and bacteriologist.

Following the preface and introduction the subjects treated by chapters are as follows: Extracellular Bacteria and Insects; Specific Bacteria Associated with Insects; Intracellular Bacterium-like and Rickettsialike Symbiotes; Rickettsiae; Yeasts and Insects; Fungi and Insects; Viruses and Insects; Spirochetes Associated with Insects and Ticks; Protozoa and Insects (except termites); Protozoa in Termites; Immunity in Insects; and Methods and Procedures.

There are 87 pages of references indicating the enormous amount of material reviewed in preparing the book. The 250 text figures, an author index and subject index complete the book.—R. H. D.

Insect Microbiology, by Edward A. Steinhaus. Comstock Publishing Company, Ithaca, N. Y. x+173 pp 1945. Price, $7.75.

OHIO ROBBER FLIES IV

(DIPTERA: ASILIDAE)

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With the passing years a number of new Asilid records for the State of Ohio have accrued. My "Preliminary Annotated List of the Robber Flies of Ohio" was published November 1, 1931, by the Ohio State Archaeological and Historical Society. This publication listed a total of 65 species of this group of flies for Ohio. Subsequently "Additions to the Ohio List of Robber Flies," published in the *Ohio Journal of Science*, vol. 33, no. 3, May, 1933, listed 5 more; "Additions to the Ohio List of Robber Flies II," *Ohio Journal of Science*, vol. 34, no. 3, May, 1934, listed 4 more and "Additions to the Ohio List of Robber Flies III," *Ohio Journal of Science*, vol. 36, no. 3, May, 1936, listed 3 more, making a total of 77 species as of 1936.

Since then, 13 more species, the specimens now incorporated in the Ohio State Museum collection (Dr. E. S. Thomas in charge) or in the Ohio State University collection in the Botany and Zoology Building (Dr. Josef Knull in charge) have been added.

78. **Dioctria baumhaueri** Meigen. Columbus, Franklin County, June 27, 1937, collected by C. L. Ward. This is our only introduced Asilid—a common European species first found in this country at Boston, Massachusetts, in 1916 by C. W Johnson.

79. **Cyrtopogon laphriformis** Curran. Hocking County, Ohio, May 23. D J. and J. N. Knull. A beautiful grayish species with orange pile on the abdomen.

80. **Laphria ithypyga** McAtee. Seven males, two females, Lancaster, June 15–27, 1943 and 1944. R. M. Goslin.

    Of the same size and appearance as *index* McAtee, but differs in the structure of the male genitalia.

81. **Asilus maneei** Hine. Mound City, August 10, 1941, R. M. Goslin, E. S. Thomas and S. W. Bromley. Eleven specimens collected.

    A small blackish-gray species usually found resting on tree trunks.

82. **Leptogaster tenuipes** Loew. Two females, July 22, 1944, Alum Creek, Columbus. R. M. Goslin.

83. **Leptogaster virgatus** Coquillett. Ross County, Colerain Township, June 21, 1936. R. M. Goslin.

84. **Ceraturgus dimidiatus** Macquart. Three males, two females, Wooster, Wayne County, June 15, 1937. Dale Jenkins and D. J. Borror. A male East Union, Wayne County, same date.

    Holmesville, Holmes County, 2 males, 2 females, June 15-20, 1937. R. T. Everly.

85. **Bombomima posticata** Say. Hocking County, "Neotoma," May 24, 1936. E. S. Thomas. Same locality, June 6, 1936. D. W. Jenkins.

86. **Cerotainia albipilosa** Curran. Athens, July 20. W. C. Stehr. I doubt if this is specifically distinct from *C. macrocera* Say.

87. **Leptogaster favillaceus** Loew. Newark, June 17, 1931. R. M. Goslin. Colerain, Ross County, June 13, 1937. R. M. Goslin.

88. **Leptogaster eudicranus** Loew. Delaware County, July 4. D. J. & J. N. Knull.

89. **Asilus virginicus** Banks. "Neotoma," Hocking County, June 6, 1937. E. S. Thomas.

90. **Asilus erythocnemius** Hine. Columbus, University Farm, August 5, 1943. Howard W. Smith.

Another individual of the excessively rare *Dasylechia atrox* Williston was taken on the O. S. U. Campus in Columbus flying around inside the class room in the Botany and Zoology Building on July 5, 1942, by R. W. Strandtmann.

Certain Asilids kill honey-bees and are known as "Bee-Killers." Twelve species have been taken with honey-bee prey in Ohio, but in no case were the flies sufficiently numerous to cause economic losses to apiarists.

	Bee-killers	Number of honey-bee prey
1.	*Promachus vertebratus* Say	28
2	*Mallophora orcina* Wied.	21
3.	*Diogmites discolor* Loew	17
4.	*Promachus bastardii* Macq	15
5.	*Diogmites umbrinus* Loew	9
6.	*Bombomima thoracica* Fabr.	9
7.	*Promachus hinei* Bromley	8
8.	*Proctacanthus milbertii* Macq	4
9.	*Proctacanthus hinei* Bromley	4
10.	*Proctacanthus duryi* Hine	4
11.	*Promachus rufipes* Fabr.	1
12.	*Erax aestuans* L	1

Three species in the environs of Columbus were seen killing the honey-bee. These were *Bombomima thoracica* Fabr. found along the sunny edges of woods, orchards and around bee hives in May and June; *Diogmites discolor* Loew around rank herbage, flower gardens, edges of fields and woods, and in apiaries during July and August; and *Promachus vertebratus* Say which occurs in clover fields, and iron-weed swales and pastures during August and early September.

Bombomima thoracica Fabr. is a remarkable mimic of a female bumblebee and is the insect to which many bee-keepers refer when speaking of the "bumble-bee" that catches honey bees.

In the Hocking Hills, 25 or 30 miles to the Southeast of Columbus, two other bee-killers, in addition to the three above mentioned, are common. These are *Diogmites umbrinus* Loew and *Promachus bastardi* Macquart. Both frequently haunt apiaries.

In the Cincinnati area, in addition to the five preceding species, there are three more, important bee-killers: *Mallophora orcina* Wied., the notorious "Southern Bee-killer," occurring in flower gardens, Joe-Pye weed swales, and around apiaries; *Proctacanthus milbertii* Macquart, the so-called "Missouri Bee-killer," which actually feeds largely on grasshoppers and butterflies in old sandy Andropogon and goldenrod fields, only occasionally taking honey-bees; and *Promachus hinei* Bromley, a large powerful robber fly frequently seen alighting on fence posts or barbed wire along cultivated fields in low ground, swales, among moist or rank herbage, or in low open woodlands in alluvial somewhat sandy soil.

The large red *Proctacanthus hinei* Bromley is found in sandy areas along Lake Erie and the Ohio River, while the smaller tan-colored *Proctacanthus duryi* Hine occurs in similar situations along the Ohio River. Both are Bee-killers.

The two remaining species, each with a single honeybee record are worthy of comment. *Promachus rufipes* Fabr., the so-called "Bee Panther," common in the South Atlantic coastal region, is rare in Ohio and confined to the Southeastern part of the State, while *Erax aestuans* L. is a very common summer Asilid throughout most of the State. *E. aestuans* feeds largely on small Diptera, being particularly fond of house and stable flies, and its capture of honey-bees is a rare occurrence.

NEW NORTH AMERICAN COLEOPTERA)
(BUPRESTIDAE, SCHIZOPODIDAE AND CERAMBYCIDAE)

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Department of Zoology and Entomology,
The Ohio State University

Juniperella n. g.

Head convex, wider on front than on vertex; front not narrowed by insertion of antennae; epistoma broadly emarginate in front; antennal cavities small, round, situated near lower portion of eyes; antennae not reaching hind angles of pronotum when laid along side; scape narrow, elongate, cylindrical; second segment about twice as long as wide, cylindrical; segments four to ten inclusive elongate, flattened, serrate; last segment elongate, narrower than preceding segments.

Pronotum twice as wide as long, widest at base; side margin extending to middle; disk convex, without callosities. Scutellum small.

Elytra at base wider than pronotum, widest back of middle.

Prosternum convex, anterior margin truncate, prosternal process slightly expanded back of coxal cavities, acuminate at apex. Suture of mesosternum quite indistinct.

Posterior coxal plates only slightly dilated internally, posterior margin nearly straight, cut off externally by abdomen; epimera of metathorax uncovered, triangular; mesosternum and metasternum closely united, suture fine.

Legs slender, tibiae straight, subcylindrical; tarsi slender, posterior tarsi only slightly longer than those on other two pairs of legs, fourth segment not lobed, claws normal.

Genotype: *Juniperella mirabilis* n. sp.

This genus should be placed in the *Buprestini* next to *Buprestis*. It is more robust and convex, prosternal process acuminate at apex, and sides of coxal plates more parallel.

Juniperella mirabilis n. sp.
(Fig. 2)

Short, very robust, shining; head, prothorax and scutellum bright metallic green; elytra dark green with four transverse, wide yellow bands not reaching suture; short pubescence on head and ventral surface only.

Head convex, densely, rather coarsely punctured.

Pronotum twice as wide as long, wider at base than at apex; sides broadly rounded from base to apex; anterior margin sinuate, median lobe small; posterior margin more strongly sinuate, median lobe broad; disk convex, slight depression in front of scutellum; surface densely, coarsely punctured, punctures closer on sides, larger than on head. Scutellum small, rounded in rear.

Elytra at base wider than pronotum, widest back of middle; sides subparallel near base, expanded back of middle, then broadly rounded to suture, forming an obtuse angle; margin serrulate near apex; disk convex, depressions lacking; surface glabrous, with very faint traces of costae, minute punctures dense.

Abdomen beneath densely, coarsely punctured; last visible abdominal segment more coarsely punctured; sides serrulate; strongly converging, apex truncate.

Length, 19 mm.; width, 8.5 mm.

Holotype of undetermined sex, collected from juniper (*Juniperus californica* Carr.) at 4,000 ft. elevation in Santa Rosa Mountains, California, June 25, 1946, by D. J. & J. N. Knull. Holotype in collection of author.

On branch where adult was taken was a fresh emergence hole which leads writer to believe that this is the species which breeds in living junipers in that locality. Eggs are evidently laid near base of tree and young larvae work in the roots. When a larva nearly reaches maturity it travels up the trunk from four inches to as high as three feet boring under bark and channeling outer sapwood. A pupal cell is constructed in sapwood and the oval opening which is tightly plugged with fine granular frass is transverse with grain of the wood. All work goes on under the shreddy bark and until the emergence hole appears it is difficult to find infested trees. Trees containing work are usually in very unhealthy condition.

Hesperorhipis hyperbolus californicus n. subsp.

Figs. 4 and 5

Male.—Differs from male of *hyperbolus* Knull by having dark area at base of elytra more metallic green, or blue, than head and pronotum and light median area of elytron not extending up around inside of umbone. Ventral surface of abdomen more rugose; last ventral segment more narrowly and deeply emarginate at apex.

Length, 4.7 mm ; width, 1.4 mm.

Described from a series collected at 4,000 ft. in Santa Rosa Mountains, California, June 5 and July 4, 1946, by D. J. & J. N. Knull. Holotype male and paratypes in collection of writer, paratype in collection of The Ohio State University.

Variations.—Length of specimens ranges from 4.7 mm. to 2.7 mm.

Chrysobothris santarosae n. sp.

Figs. 10 and 11

Male.—Robust, convex; head, prothorax and ventral surface dark, shining, cupreous; elytra darker, opaque.

Head convex; surface with longitudinal smooth carina on occiput which is striate in middle, joining similar smooth areas on each side of front, forming a Y, another smooth area below Y, area between callosities densely, irregularly, coarsely punctured; clypeus truncate, faintly emarginate in middle; antennae not extending to middle of pronotum when laid along side.

Pronotum convex, much wider than long, widest in middle; sides rounded; anterior margin only slightly lobed; basal margin strongly sinuate; surface densely coarsely punctured, punctures confluent at sides. Scutellum small, triangular.

Elytra at base wider than widest part of pronotum, not entirely covering abdomen, sides subparallel basally, broadly rounded back of middle to rounded apices, serrulate; disk convex, two basal depressions each side, void of costae; surface finely, densely punctate, punctures larger and denser along outer margin.

Abdomen beneath coarsely, densely punctured, last visible segment without serrations, broadly emarginate at apex, with ridge on apical half extending across apex. Prosternum with anterior margin broadly rounded, deflexed. Anterior femur with obtuse tooth serrulate on outer margin. Anterior and middle tibiae arcuate, unarmed.

Length, 10.7 mm.; width, 4.2 mm.

Described from a male specimen in the collection of writer taken at 3,500 feet in the Santa Rosa Mountains, California, on June 15, 1946, by D. J. & J. N. Knull.

According to Fisher's key[1] it would run to *C. platti* Caz. It differs by the dark color as well as the coarsely punctured pronotum with smooth intervals.

Agrilus gillespiensis n. sp.

Figs. 6 and 7

Male.—Narrow, elongate; form of *A. celti* Knull; dark bronze throughout, front of head metallic green.

Head convex, depression on vertex slight; surface granulose on front, finely strigate on vertex; antennae extending beyond middle of pronotum when laid along side, serrate from the fifth segment.

Pronotum wider than long, wider in front than in rear; side margins converging in front, sinuate near base; anterior margin sinuate, median lobe prominent; basal margin sinuate; disk convex, lateral depression each side, prehumeral carina nearly parallel to side margin; when viewed

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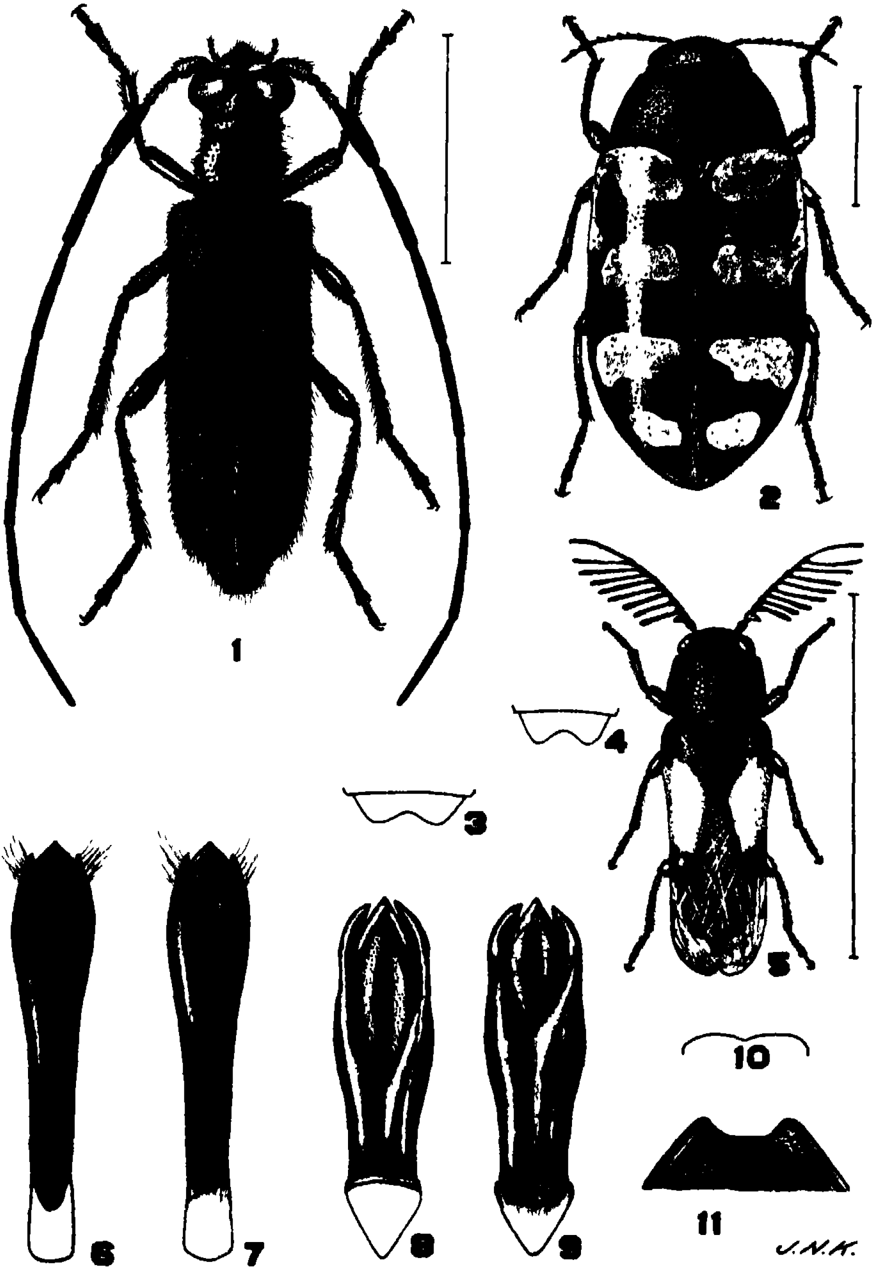
[1] W. S. Fisher, U. S. D. A. Misc. Pub. 470, pp. 1-275, 1942.



1. *Centrodera osburni* n. sp. ♂. 2. *Juniperella mirabilis* n. sp. 3. *Hesperorhipis hyperbolus* Knull, last visible ventral abdominal segment. ♂. 4. *Hesperorhipis hyperbolus californicus* n. subsp., last visible ventral abdominal segment. ♂. 5. *Hesperorhipis hyperbolus californicus* n. subsp. ♂. 6. *Agrilus gillespiensis* n. sp., dorsal view of ♂ genitalia. 7. Ventral view of number 6. 8. *Chrysobothris santarosae* n. sp., dorsal view of ♂ genitalia. 9. Ventral view of number 8. 10. *Chrysobothris santarosae* n. sp., anterior margin of clypeus. 11. *Chrysobothris santarosae* n. sp., last visible ventral abdominal segment ♂.

Line equals 5 mm.

from side, marginal and submarginal carinae separated for entire distance, joined at base; surface finely, obliquely transversely strigose. Scutellum transversely carinate.

Elytra elongate, at base wider than base of pronotum; sides subparallel at base, constricted at middle, expanded back of middle, then converging to rounded, serrulate apices; disk convex, a basal depression each side, surface imbricate, pubescence inconspicuous.

Abdomen beneath minutely punctate, first ventral segment flattened in middle, flat area higher than second segment. Prosternum pubescent; prosternal lobe broadly rounded in front, lacking an emargination. Posterior coxal plates broadly emarginate in rear, outer posterior angle rectangular. Anterior and posterior tibiae mucronate on inner margin at apex. Tarsal claws similar, outer tooth long, acute; inner tooth short and broad.

Length, 5 mm.; width, 1.3 mm.

Female.—Differs from male by having front of head cupreous; first two ventral segments convex and tibiae unarmed at apices.

Holotype male and allotype collected in Gillespie Co., Texas, May 7, 1946, by D. J. & J. N. Knull and in collection of writer.

According to Fisher's key[2] this species would run to *A. celti* Knull. It differs by having lateral carinae of thorax separated for entire distance, prehumeral carina parallel to side margin, prosternal lobe broadly rounded, and shape of male genitalia.

Dystaxia murrayi cuprea n. subsp.

Female.—Size and form of *murrayi* Lec.; cupreous with green luster above and below; antennae, mouth parts and legs light brown. Compared with *murrayi* the anterior margin of epistoma is less deeply emarginate; antennae are shorter, extending one segment beyond hind angles of pronotum when laid along side, segments six to eleven inclusive proportionately shorter.

Length, 11.5 mm.; width, 6 mm.

Described from holotype female in collection of writer labeled Cajon Pass, California, June 26, 1941, D. J. & J. N. Knull collectors.

Gymnospyra notabilis n. sp.

Female.—Narrow, elongate; moderately shining, dark brown; legs and ventral surface lighter; head and pronotum with long, erect setae; elytra with densely recumbent pubescence, also scattered long erect setae.

Head convex, punctures large, confluent; eyes prominent, coarsely granulate; antennae not reaching end of abdomen when laid along side, scape stout, second segment slightly longer than wide, third shorter than scape, fourth longer than third, fifth longer than fourth, sixth equal to fifth, seventh shorter than sixth, eighth shorter than seventh, ninth equaling eighth, tenth shorter than ninth, eleventh longer than tenth, first four segments subcylindrical, densely coarsely punctured, segments five to ten inclusive somewhat flattened and slightly serrate, finely punctate.

Pronotum about as long as wide, widest in middle, base and apex of about equal width; sides broadly rounded, constricted at base and apex; anterior margin rounded; basal margin broadly emarginate; disk convex; surface densely, coarsely punctured. Scutellum transverse, broadly rounded in rear.

Elytra at base much wider than pronotum, elongate; sides subparallel, broadly rounded near apex to rounded apices; disk convex, a slight basal depression on each elytron; surface densely coarsely punctured at base, punctures becoming obsolete at apex, largest punctures much smaller than on pronotum.

Abdomen beneath shining, sparsely, finely punctate, pubescence long, slender. Anterior coxal cavities open behind, angled on outside; anterior tibiae carinate on outside.

Length, 13.7 mm.; width, 3.3 mm.

Holotype female in collection of writer labeled Jacumba, California, May 18, 1941, D. J. & J. N. Knull collectors.

This species appears to fit *Gymnospira* Lins. better than any other genus in our fauna, although it lacks antennal spines.

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[2] W. S. Fisher, U. S National Mus. Bul. 145, pp. 1–347, 1928.

Centrodera osburni n. sp.

Fig. 1

Male.—Narrow, elongate; color dark brown throughout, shining, moderately pubescent.

Head wider than pronotum; surface coarsely punctured; eyes large, coarsely granulate; antennae extending two segments beyond apices of elytra when laid along side, scape stout, second segment as long as wide, third segment slightly longer than wide, longer than fourth, fifth as long as first three united, sixth longer than fifth, seventh and eighth equal, each longer than sixth, ninth and tenth equal, each shorter than eighth, eleventh longest, first four segments similar, shining, coarsely punctured, following segments flattened, opaque, minutely punctate.

Pronotum wider than long, widest in middle, base and apex of equal width; sides sinuate with rounded tubercle each side at middle; apical margin rounded; basal margin sinuate; disk convex, with transverse depression back of apex and at base, slight trace of median depression, rest of area somewhat irregular; surface coarsely, irregularly punctured all but middle line where punctures are small and sparse. Scutellum rounded in rear.

Elytra at base wider than head; sides subparallel, broadly rounded on apical fourth to rounded apices; disk convex, basal depression on each elytron shallow, lacking costae, surface rugulose, densely, finely punctured.

Abdomen beneath smooth, sparsely, finely punctate, densely punctured depressed area on each side of first four segments, last visible segment more densely punctured than others, truncate at apex. Tarsi on first two pairs of legs about equal, posterior tarsi slightly longer.

Length, 12.2 mm.; width, 3.5 mm.

Described from four male specimens collected at 6,000 ft. in the New York Mountains, California, September 11, 1945, by Dr. R. C. Osburn. Holotype and paratypes in collection of The Ohio State University, paratype in collection of writer.

This species can be distinguished by the short second, third and fourth antennal segments.

BACTERICIDAL EFFECT OF THE WAR-TIME PENNY

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The copper penny has long been known to have bactericidal qualities and has been used in the classroom to illustrate such properties, likewise, it has been utilized in small aquaria and reservoirs for the purpose of inhibiting the growth of minute organisms. With the Government's issue of the new war-time penny a study was made to find if this coin produced similar effects and how they compared with those of the copper penny.

Both the copper penny and the war-time penny were placed upon sterile agar in a sterile Petri dish. The plate was exposed to the air for 15 minutes to assure bacterial inoculation. All the dishes remained at room temperatures for the entire experiment. Measurements of the inhibiting zone (Table I) and photographs (Fig. 1) of the plates were recorded at the following intervals: 72 hours, 144 hours, and 240 hours..

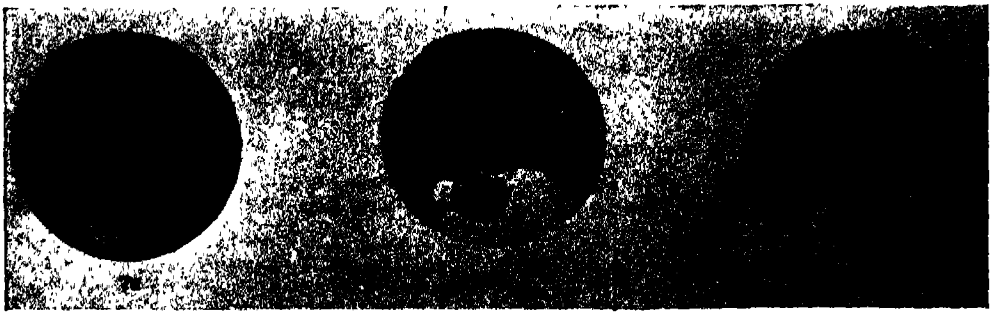

FIG. 1. Photographs of the development of the whitish area at the following intervals: left, 72 hours; center, 144 hours; and right, 240 hours. The copper penny is above and war-time penny below.

Within twenty-four hours after the war-time penny had been placed upon an agar plate a large whitish area formed immediately surrounding the coin (Fig. 1). At first this area was believed to be bacterial growth but because of its color and smooth peripheral edges, suspicion warranted a more detailed examination. One hundred Petri dishes were divided into five groups, twenty in each. They were handled in the following manner: the first group was set up with sterile Petri dishes, sterile pennies and sterile agar; the second group was made up with sterile dishes, sterile pennies and sterile agar, but these plates were streaked with a known bacterium; the third was prepared with sterile dishes, sterile agar and nonsterile pennies; the fourth group was composed of sterile agar, nonsterile dishes and nonsterile pennies and the fifth group, or control group, contained only sterile dishes and sterile agar. Both copper and war-time pennies were used in each of these plates.

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[1] The author wishes to thank Fred. H. Norris, Department of Botany, for his aid with this experiment.

Between 18 and 24 hours after the material had been set up a whitish area appeared around the war-time pennies on all the plates but did not appear around any of the copper pennies. In the majority of plates it appeared before any signs of bacterial growth.

Material was taken from the whitish area of group one and was transferred to agar slants for culturing. No growth appeared on any of the twenty-four slants used. At the same time that the transfers were made, stained smears from the same area were prepared and studied. The smears were found to be free of organisms.

TABLE I
WIDTH OF INHIBITING ZONE

	72 Hours	144 Hours	240 Hours
Copper Penny.	12 mm.	19 mm.	21 mm.
War-time Penny	17 mm.	17 mm.	19 mm.

After 144 hours from the beginning of the experiment an inhibiting zone appeared around the whitish area of the war-time penny. This zone was not large but was clear of bacterial growth and remained so for ten days after the last recorded record. No bacterial colonies were observed on or in the whitish area, the effect seemed to extend in three dimensions.[2] The lack of growth on the slants made from the transfers, the absence of visible organisms in the smears and the production of an inhibiting zone around the whitish area seem to indicate that this whitish area around the war-time penny[3] is a diffusable precipitate or colloid rather than a bacterial growth. The copper penny produced an inhibiting zone that was in diameter 2 mm. larger than the war-time penny.

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[2] Nadson, G. A., et C. A. Stern, De l'action a distance des metaux sur les bacteries et les levures. Compt. Rend. Acad. Sci. (Paris) 194 (18): 1597-1600. 1932.

[3] This coin contains steel compounds coated with an alloy of zinc.

NEW FULGOROIDEA FROM NORTH AMERICA (HOMOPTERA)

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Oliarus acicus n. sp.

Length, male, 5 mm.; female, 5.8 mm. Black over all with pronotal and facial carinae dark brown. Elytra with veins and stigma black in male; veins brown in female with apex of claval suture blackened.

Vertex long, narrow, deeply notched caudad. Profile rounding. Face polished, tumid, oval in outline; median carina prominent on frons and clypeus. Mesonotal carinae prominent but concolorous with mesonotum. Elytra with veins scarcely punctate; claval veins united in basal fourth; five anteapical cells present. Post tibiae each with two preapical spurs.

Anal segment of male with long, acute, apical tooth projecting inward to genital cavity. Pygofers with either lateral magin produced caudad and basad in lateral aspect. Forceps not greatly enlarged apically; apices recurved, acute in lateral aspect. Aedeagus with two processes; the more apical process long, recurved.

Male holotype and paratype, Brownsville, Texas, 2-19-46, (Caldwell); female allotype and eleven paratypes, and one male paratype, Hermosillo, Sonora, 3-23-27, (MF 1220, Dampf); one female paratype and two male paratypes, Yaqui Valley, Sonora, 11-19-35, (MF 3980, Dampf); and a female paratype, El Dorado, Sinola, 1-22-30, (MF 1566, Dampf).

This species is common in insect collections from southwestern United States under the name *complectus* Ball from which it differs by having a longer tooth on the anal segment, a smaller periandrium without processes, and only two aedeagal processes.

Oliarus ecologus n. sp.

Length of male, 4.5 mm.; female, 5.5 mm. General color black. Carinae of face and median carina of mesonotum red; pronotal carinae light yellow. Elytra yellowish; veins and stigma yellow.

Vertex about twice as long as broad, trough-like, with median carina in basal half. Profile rounding. Median and lateral carinae of face elevated. Intermediate carinae of mesonotum curved, closer to outside than to median. Four anteapical cells present in either elytron.

Anal segment of male hood-like. Pygofer with either posterior margin evenly produced in lateral aspect; medioventral process short, triangular. Forceps broadened, evenly recurved apically. Genitalia illustrated in Ohio Biol. Sur. Bull. 35, vol. 6, no. 6, p. 301, figs. C, C 1, 1935. (Fig. C is mirror image of true position.)

Male holotype, female allotype, and many paratypes of both sexes from Pickaway Co., 7-1-36; paratypes same locality, 6-16-34, 7-8-36; Ross Co., 7-3-38; Jackson Co., 7-22-38; Licking Co., 6-16-34; and Lawrence Co., 6-24-34, all in Ohio. (Caldwell.)

Usually identified as *franciscanus* Stal but the distribution is entirely different since *ecologus* does not occur west of the Mississippi River. I have been unable to recognize *franciscanus* but it is probably one of the more common species occurring in California as an unrecognized synonym.

Oliarus zyxus n. sp.

Length of male, 5 mm. General color black with brown carinae; carinae of mesonotum reddish. Stigma and veins of elytra fuscous.

Vertex long, narrow, deep, trough-like. Face twice as broad at widest point as at apex; median carina prominent. Elytra little over twice as long as broad; punctations on veins scarcely visible; five anteapical cells present. Post tibiae with three anteapical spurs.

Anal segment of male short, hood-like. Lateral margins of pygofer greatly produced caudad; medioventral process narrow, rounded apically. Forceps long; flattened, recurved apically.

Periandrium produced into broad, flat, S-shaped structure on the left side; without a small median spur on inner margin; aedeagus with two apical and one subapical process in addition to three basal processes.

Male holotype and paratype, Nuevo Laredo, Nuevo Leon, 9–22–41, (DeLong, Good, Caldwell, and Plummer) Male paratype, El Torreon, Coahuila, (M B 237, Dampf). I have also seen examples of this species from Texas and Arizona in various collections.

Resembling *concinnulus* Fowl. and *littoralis* Ball, but differing from either by a slightly narrower vertex and in details of the male genitalia.

Cixius diastus n. sp.

Length of male, 6 mm.; female, 7 mm. Male flavous over all with black punctations on veins of elytra. Female generally flavous with lateral compartments of mesonotum slightly infuscate and with basal and apical areas as well as a median transverse stripe on elytra flavous. (Elytra is male sometimes faintly marked as in female)

Vertex narrow, U-shaped; apical compartments transverse as in *basalis* V. D. Face narrow with median carina greatly elevated. Mesonotum longitudinally flat; median carina little evident posteriorly. Elytra almost three times as long as broad; veins densely punctate, punctations mostly paired. Post tibiae with two prominent anteapical spurs.

Anal segment of male enlarged basad. Pygofer evenly rounded on either side; medioventral process very broadly triangular. Forceps obliquely truncate apically. Aedeagus with three subapical processes.

Male holotype, female allotype, seven male, and thirteen female paratypes from Mexico, D. F., 9–1–39, West 18 Km., (DeLong & Plummer)

Resembling the male of *flavo-brunneus* Fowl. but according to Mr. W. E. China of the British Museum, ". . . is quite different in structure of pygofer, styles, and aedeagus."

Gaetulia obtusa n. sp.

Length of male, 7 mm.; female, 8 mm. General color green with two longitudinal dorsal stripes beginning light yellow on vertex and deepening to dark red on mesonotum. Veins on elytra black, marginal veins yellow, stigmal area clear.

Vertex much broader than long; apex obtuse. Frons narrow, little broadened apically. Facial carinae distinct. Male with latroposterior margins of pygofer truncate. Aedeagus with one lateral and one median process projecting from theca, these processes long and slender; a pair of small acute processes present at apex. Last ventral segment of female roundedly produced caudad with small rounded median notch in posterior margin.

Male holotype, female allotype, and a male and a female paratype from Tamazunchale, S. L. P., 11–15–38, (Caldwell). Two male and three female paratypes, same locality, 8–29–39, (DeLong). One male paratype, Valles, S. L. P., 12–1–38, (Caldwell).

Resembling *plennipennis* (Walk.) in size but lacking the colored stigmal areas on the elytra and with the shorter, broader vertex.

Gaetulia vulgaris n. sp.

Length of male, 6 mm.; female, 6.5 mm. Light green in color with a pair of longitudinal dorsal stripes of varying intensity. Cephalic carina of vertex and median carina of frons black. Veins yellowish, stigmal areas clear.

Vertex as long as broad, parallel sided. Frons little longer than broad, slightly narrowed basad. Latroposterior margins of male pygofer obtusely produced. Aedeagus with broad, blunt process projecting from left side of theca; a process present on left side half distance to apex; and a pair of short, broad processes present apically. Last ventral segment of female truncate apically with a small median notch in apical margin.

Male holotype, female allotype, twenty male and twenty female paratypes from Santa Engracia, Tamps., 11–9–39, (Caldwell). Very common on grass in an orange grove.

Resembling *nigrocarinata* Fowl. but smaller and without three black mesonotal carinae.

Pseudhelicoptera protubera n. sp.

Length of female, 5.5 mm. Face yellow except black apex; sides of head yellow with a broad, ragged edged, fuscous stripe present on either side from eye to apex. Vertex black; lateral margins yellow interrupted by three black dashes on either side. Pronotum fuscous, striped with white. Elytra ferruginous, spotted with small white callouses; veins more red than membranous areas.

Vertex long, narrow, trough-like; acute apically; lateral margins thin, much elevated. Frons narrowed basally, pinched laterally at base. Pronotum projected into vertex half length of eyes. Mesonotum tricarinate. Elytra lapped apically; veins regular, parallel. Hind tibiae with small basal spur. Last ventral segment of female with large, rounded, median notch on posterior margin.

Female holotype from Suchilapa, Oaxaca, 10-11-41, (DeLong, Good, Caldwell, & Plummer). (All types are in the writer's collection.)

Resembling *nasuta* Fowl. but with vertex less declivient and with narrower face.

OTODISTOMUM PLICATUM N. SP. (TREMATODA, DIGENEA) FROM HEXANCHUS GRISEUS (BONNATERRE)

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An *Otodistomum*, differing in certain respects from the *Otodistomum veliporum* so frequently encountered in *Raja binoculata* at Friday Harbor, Washington, was obtained from the pyloric stomach of a specimen of *Hexanchus griseus* caught there during the summer of 1942. The worms, about one hundred in number, were at once noticeable because of their marked dorso-ventral compression, and because of their extreme variation in size. Living, extended specimens were observed from 10 to 105 mm. in length, with a maximum breadth of about 8 mm. Further study of fixed material has failed to identify these worms with *Otodistomum cestoides*, *O. veliporum*, or *O. pristophorus;* the species recognized in the genus. Accordingly, in spite of the somewhat tenuous distinctions which exist between the reported species it seems advisable tentatively to recognize the worm from *Hexanchus griseus* as distinct and hitherto undescribed. For this species I propose the name *Otodistomum plicatum.*

SPECIFIC DIAGNOSIS

Otodistomum plicatum n. sp.

This is an elongated, dorso-ventrally flattened worm which may exceed 100 mm. in length; with a maximum breadth of 8 mm. It is distinguished from other members of the genus by the possession of an exceptionally large cirrus pouch (1.43–2.36 x 0.84–1.57 mm.); an exceptionally small, compressed ovary (0.45–0.7 x 0.29–0.34 mm.); and an egg of unusual size (0.11 x 0.07 mm.) with a very thick shell (0.0075–0.008 mm.).

Locality: Friday Harbor, Washington.
Host: *Hexanchus griseus* (Bonnaterre).
Location in host: Pyloric stomach.
Type specimen: U. S. N. M. Helminthological Collection No. 36908.

DESCRIPTION

The living worm is elongated, ribbon-like, dorso-ventrally flattened; it is creamy white in color with the region just posterior to the ventral sucker darkened by the brown uterine eggs. Fifty-one fixed specimens varied in length from 8 to 83 mm. (average, 47 mm.) and in breadth from 3 to 7. 5 mm. (average, 5.2 mm.). Both large and small worms are, rather constantly, about 1 mm. thick; as much as 1.5 mm. at the level of the egg-filled uterus. The body is covered with folded, smooth cuticle which varies in thickness from 0.03 mm. on a 10 mm. worm to as much as 0.075 mm. on a specimen of 41 mm. As has been reported from other species, the cuticle is much thinned over the suckers; generally not exceeding 0.01 mm. in these areas.

The suckers are large and well-developed, with the oral sucker occasionally partially retracted into a fold of the anterior body. Numerous oblique bands, derived from the longitudinal muscle layer, and occupying the anterior dorsal portion of the body, control its extension and retraction. The ventral sucker extends nearly to the dorsal surface, but may be protruded considerably. The sucker diameter ratio is about 2 : 3; oral sucker from 0.9–1.5 mm., ventral sucker from 1.3–2.4 mm. in diameter.

The alimentary canal possesses no unusual features (Fig. 1). It consists of a buccal opening through the anterior sucker giving immediately on a large, muscular pharynx. This communicates with a pouch-like, thin-walled esophagus which branches laterally, and passes slightly anteriorad to either side of the pharyngeal bulb before giving way to the intestinal crura. The pharynx and esophagus are lines with a structureless membrane which is presumably continuous with the cuticle. The intestinal branches are large, more or less folded, and lined anteriorly with flattened or cuboidal epithelium from which protoplasmic processes extend into the lumen (Fig. 4). Posteriorly, particularly in immature worms, the epithelium is of a tall, columnar form, and two types of cells are present (Fig. 5); ill-defined cells bearing protoplasmic processes, and large, club-like cells filled with granules. The two crura extend almost to the posterior end of the body and may be somewhat unequal in length.

The excretory system resembles that of other members of the genus (Fig. 1). A posterior, terminal, excretory pore opens from a very large vesicle which occupies most of the posterior two-fifths of the body. Anteriorly this bladder is continued by two irregular canals which pass dorsal to the intestinal crura and continue along the lateral margin to the anterior tip of the body. The thin epithelial lining of this entire system is coated with masses of densely staining, globular bodies such as have been reported from a number of trematodes. Flame cells are abundant and widely distributed through the body.

The nervous system has not been studied in detail, but, as far as observed, it conforms to the general pattern of related species.

The organs of the male reproductive system are subject to considerable variation in size. Two testes lie one behind the other just anterior to the middle of the body (Fig. 1). The posterior testis is consistently slightly larger than the anterior (posterior, 23 mm. worm, 1.09 x 0.88 mm., anterior, 0.96 x 0.63 mm.; posterior, 58 mm. worm, 1.43 x 1.39, anterior, 1.35 x 1.31 mm.; posterior, average of ten specimens, 1.17 x 1.05, anterior, 1.08 x 0.99 mm.). From the anterior, median surface of each testicle a thin-walled, convoluted vas deferens, about 0.03 mm. in diameter, passes towards the anterior part of the body. These fuse beneath the anterior border of the ventral sucker, and immediately enter a large cirrus pouch to enlarge into a swollen, comma-shaped, seminal vesicle (Fig. 3). The seminal vesicle is lined by flattened epithelium and surrounded by sparse bundles on longitudinal muscle fibres which are continuous with the outer muscle layer of the ejaculatory duct. This duct arises from the anterior end of the seminal vesicle. It is lined with a low cuboidal epithelium and has both circular and longitudinal muscle layers. After coiling considerably, it emerges from the cirrus pouch near the anterior end, losing its epithelium which is replaced by thin cuticle. The ejaculatory duct terminates within the genital cone where it unites with the uterus before opening through the tip of the cone into the genital atrium. The cirrus pouch is a large, encapsulated, ovoidal structure lying dorsal and anterior to the anterior border of the ventral sucker in the left half of the body. In length it varies from 1.43 mm., in a 23 mm. worm, to 2.36 mm. in a 48 mm. worm; the average is about 1.97 mm. The peripheral portion of the pouch contains many cells similar to those which have been described as prostatic cells; the central portion is largely made up of loose fibres ramifying about the seminal vesicle and its associated ducts. The entire pouch is surrounded by a thin, irregular layer of muscle fibres.

The ovary is small and antero-posteriorly compressed. Size: 0.45 x 0.29 mm. in a 23 mm. worm; 0.7 x 0.34 in a 48 mm. worm; average, 0.61 x 0.30 mm. At most a few dozen developing ova are present at any one time, and a very few primitive oocytes. The organ is invested with a fibrous capsule which, on the anterior surface, is reflected inward to surround the funnel-like beginning of the oviduct (Fig. 7). A peculiar ring of ciliated cells lies on the ovarian side of this membrane, immediately about the opening of the oviduct (Fig. 8). These possibly aid in directing the mature ovum into the duct.

Initially the oviduct is lined with a flat, pavement epithelium. The posterior portion takes a somewhat tortuous, anterior course and is joined, dorsally, by Laurer's canal and the common yolk duct (Fig. 2). It then enlarges slightly, and its lining changes to cuboidal, apparently ciliated, cells while it is surrounded by a thick layer of Mehlis' glands (Fig. 2, 7). At this point the duct may be considered an ootype. This ootypical portion is thrown into one or two transverse folds before losing its epithelial lining and becoming the membranous, egg-filled uterus.

Laurer's canal passes from its opening in the dorsal body wall to the oviduct along a variable course which typically passes just anterior to the ovary in the mass of loose connective tissue surrounding the ootype and terminates in the portion of the oviduct immediately posterior to the ootype. The common vitelline duct enters the oviduct at approximately the same point. This vitelline duct is the terminal portion of a dorsal yolk reservoir which is partially imbedded in the ootype capsule. The reservoir (Fig. 2) is an irregularly triangular body formed by the fusion of the lateral vitelline ducts which collect material from vitellaria distributed along the surface of the intestinal crura.

Anterior to the ootype the uterus is thrown into a series of transverse folds extending slightly beyond the posterior border of the ventral sucker. The anterior portion of the uterus (Fig. 1) passes dorsad to the right margin of the sucker to emerge ventrad to the median surface of the cirrus pouch in the mid-line of the body where it continues, with few convolutions, to enter the genital cone near its apex. The terminal portion of the uterus forms a strongly muscular metraterm, and well-developed circular and longitudinal muscle layers extend to the point where it fuses with the ejaculatory duct.

Eggs are very numerous and yellowish to dark brown in color. They are about 0.11 x 0.007 mm. in size and are surrounded by an exceptionally thick shell, 0.0075–0.008 mm. in thickness (Fig. 6). No attempt was made to study the intrauterine development of the egg, but the miracidia are apparently well-differentiated in the terminal part of the uterus.

The common portion of the genital apparatus consists of a cone (0.15 x 0.225 mm. in a moderately expanded specimen) in which the genital ducts unite, a genital atrium, and a genital pore. The atrium (Fig. 3) is an elongated chamber extending antero-ventrad from the genital cone to the genital pore. It may be subdivided into two parts: a posterior, enlarged chamber enclosing the genital cone, and an anterior tube terminating at the pore. The whole structure is lined with cuticle which becomes very thin near the tip of the cone. The musculature is complex; a circular layer extends the length of the atrium and is thickened into heavy rings in the wall of the posterior chamber; a number of longitudinal bundles are present, forming an incomplete layer; and fibres from the longitudinal muscles of the body wall extend obliquely to the wall of the anterior tube. These probably function together in the eversion and retraction of the cone. The total length of the atrium approximates a millimeter about equally divided between the two sections; the maximum diameter of the posterior portion is about 0.3 mm. while the anterior portion is half as broad. While the spatial relationships of the parts vary the structural details seem rather constant. Unfortunately no worms were available with the cone everted so that it was impossible to determine what changes in relationship this action would produce. The genital pore lies ventral to the esophagus and just posterior to the pharynx. About its margin the cuticle is thrown into folds which often take the form of small, inwardly directed papillae.

DISCUSSION

The characters by which species of *Otodistomum* are distinguished are far from satisfactory. Between the reported species there is very considerable overlapping of characters. Yet Manter's careful and detailed study (1926) left him unwilling to disturb the existing taxonomy although, after critical comparison of *Otodistomum cestoides* and *O. veliporum* he ends by finding that, "The most certain distinction is egg size." *O. pristophorus* (Johnston, 1903) is distinguished by its peculiar, coelomic habitat; but, morphologically, Odhner (1911) considered it identical with *O. veliporum*. The confirmation of its coelomic occurrence (Woolcock, 1934) suggests that it is probably specifically distinct.

In comparing *Otodistomum plicatum* with *O. veliporum* collected in the same area, and with published descriptions of *O. veliporum* and *O. cestoides* the condition observed by Manter is evident; the worm is visibly different, but clear-cut, diagnostic characters are few. As he found, the egg size seems to be the most constant character, and this size is considerably above any previously reported in the genus. The ovary is regularly compressed and is smaller than that of comparable specimens of *O. veliporum* which I have examined or of *O. veliporum* and *O. cestoides* as given by Manter. However, the latter's work makes it doubtful that either size or position of gonads can be considered as distinguishing factors in this genus. The genital atrium appears distinctive, but the absence of specimens with everted cones makes it impossible to assess the diagnostic value of this character. The relatively immense cirrus pouch is the most clear-cut point of divergence between *Otodistomum plicatum* and its congeners. This difference appears early; an incompletely mature worm of 14 mm. had already a pouch length of 1.31 mm., *i.e.*, greater than that of the average adult of *O. cestoides* or *O. veliporum* (Manter, 1926). On the basis of these differences, then, if we recognize more than a single species in the genus, *Otodistomum plicatum* must be regarded as specifically distinct.

SUMMARY

A new species of *Otodistomum* is described from *Hexanchus griseus* (Bonnaterre). It is distinguished by unusual size of egg and cirrus pouch.

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EXPLANATION OF PLATE

All stated magnifications are those at which the figures were drawn; reduction in reproduction is indicated by a five centimeter line accompanying the plate. The following abbreviations have been used:

A	genital atrium.	P	cirrus pouch.
E	ejaculatory duct.	SV	seminal vesicle.
L	Laurer's canal.	U	uterus.
M	Mehlis' gland.	VD	vas deferens.
O	ootype.	YD	vitelline duct.
OV	oviduct.	YR	yolk reservoir.

Fig. 1. Ventral view of entire worm. × 10.

Fig. 2. Reconstruction of the ootype and related structures. The parenchymatous capsule has been omitted. × 120.

Fig. 3. Reconstruction of the terminal genital ducts. × 40.

Fig. 4. Section through the anterior intestinal wall showing low cells and filamentous processes. × 1000.

Fig. 5. Section through the posterior intestine of an 11 mm. worm showing two cell types. × 1000.

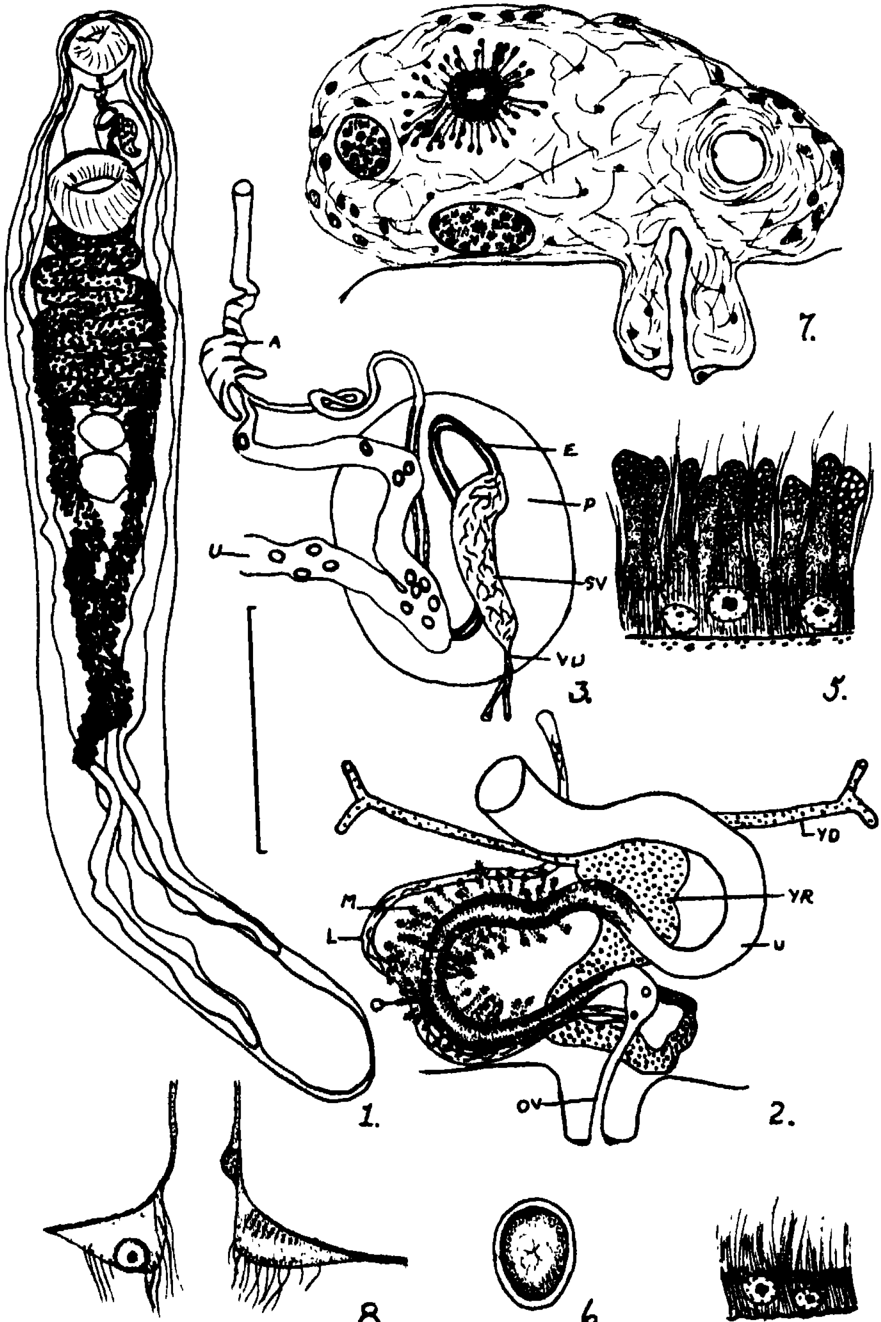
Fig. 6. Uterine egg. × 200.

Fig. 7. Section through the ootype capsule. × 200.

Fig. 8. Section through beginning of oviduct showing ciliated ring. × 1000.

Otodistomum plicatum n. sp.
Maire Weir Kay

PLATE I



A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF THE HEART—AVES V—SPHENISCIFORMES

PART 2[1]

FRED H. GLENNY,[2]
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The writer was fortunate in obtaining a single specimen of the Emperor Penguin, *Aptenodytes forsteri* (No. 106141), from the anatomical collections of the Chicago Natural History Museum, for this study.

In a previous paper (Glenny, 1944), the writer presented the arrangement-pattern of the main arteries of the neck and thorax of five species of Penguins. The arrangement of these same arteries in *Aptenodytes forsteri* is essentially the same as that of *Spheniscus demersus* (Glenny, 1944).

Minor differences may be noted, but these lie within the range of normal vascular variation, and are not to be regarded as being particularly significant as specific characteristics.

OBSERVATIONS

The subclavian artery and its branches are the same as in *Spheniscus demersus*. Both the right ligamentum botalli and the left ligamentum aortae are present in the adult.

Some differences are found in the arteries arising from the common carotid artery. The thyroid arteries arise from the short common carotid arteries posterior to the point of origin of the internal carotid (trunk) artery, superficial artery, and vertebral artery. These three arteries arise together from the common carotid artery. The subscapular artery arises from the superficial cervical artery, shortly after it branches from the common carotid.

The right superficial cervical artery comes to serve as the ascending-oesophageal artery. No major secondary branches were found arising from the superficial cervicals.

CONCLUSIONS

The thoraco-cervical arterial arrangement-pattern in *Aptenodytes forsteri* does not appear to deviate greatly from the general Sphenisciformes pattern.

In effect, the arrangement-pattern presented by *Aptenodytes* might be considered to be a basic ordinal arrangement-pattern, rather than a more highly specialized type which might be expected in a terminal species.

It is within the realm of possibility that *Aptenodytes* has retained the generalized arterial pattern which may have been present in an earlier, now extinct, ancestral form.

Close similarity in the arterial arrangement-patterns in six species of penguins, thus far studied, might lead one to conclude that this group of birds has almost completely run its course of divergences in the arterial pattern, and that, although there are relatively few extinct species, they show a high degree of similarity in structure and arrangement of arteries.

REFERENCE

Glenny, F. H. 1944. A systematic study of the main arteries in the region of the heart—Aves V—Sphenisciformes. Part I. Ohio Journal of Science, 44 (1): 28–30.

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[1] Contributions from the Blue Sea Lake Biological Laboratory, Messines, P. Q.

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SOME ALGAE, INCLUDING NEW SPECIES, FROM NEW MEXICO[1]

CLARENCE E. TAFT,
The Ohio State University

The writer recently had the opportunity to examine several collections of algae from Valle Grande, in the vicinity of Los Alamos, New Mexico. The samples were collected by Dr. R. A. Popham, Department of Botany, The Ohio State University, during the spring of 1944 and the early summer of 1945 from an elevation approximating 9,000 feet.

The algal flora of New Mexico is generally unknown. As indicated by these samples, it would be well worth the time of some algologist to carefully survey this area by extending the time and scope of the collections. Although no fruiting Oedogoniaceae and only one member of the Zygnemataceae in fruit was discovered, members of both groups were numerous in vegetative condition. The paucity of fruiting material in either of these groups in alpine or subalpine habitats is notorious. Yet extensive collecting might result in some remarkable records. The large proportion of desmids in the collections is merely characteristic of alpine or subalpine regions and is probably indicative of a rich flora. No attempt has been made to identify the diatoms, which although numerous, do not predominate in the collections examined.

The writer is indebted to Dr. Popham for the samples and expresses his appreciation for the time and effort expended in their acquisition. He also wishes to thank Dr. G. W. Prescott of Michigan State College, Lansing, Michigan, for the use of his Iconograph of the Desmidiaceae as well as for his helpful comments and criticisms in species determination.

SPECIES LIST

CHLOROPHYTA

Volvocaceae
    Pandorina morum Bory.
    Volvox aureus Ehr.
Tetrasporaceae
    Apiocystis brauniana Nag.
    Gloeocystis ampla Kutz.
    Sphaerocystis schroeteri Chodat.
    Tetraspora lubrica (Roth) Ag.
Ulotrichaceae
    Ulothrix zonata (Weber & Mohr) Kütz.
Chaetophoraceae
    Microthamnion strictissimum Raben.
Zygnemataceae
    Spirogyra tenuissima (Hass.) Kuetz.
Desmidiaceae
    Closterium kuetzingii Bréb.
    Closterium moniliferum (Bory) Ehr.
    Closterium pritchardianum Archer.
    Closterium striolatum var. *subtruncatum* (W. & W.) Krieger.
    Closterium tumidum Johnson.
    Micrasterias americana (Ehr.) Ralfs.
    Euastrum bidentatum Näg.

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[1] Paper from the Department of Botany, The Ohio State University, No. 492.

Euastrum denticulatum (Kirchn.) Gay.

Euastrum notatum Taft sp. nov. Fig. 2.

Cells small, longer than broad, constriction shallow and open; semicells quadrate-pyramidate, lateral margins concave; polar lobe nearly quadrate, apex slightly retuse and surrounded by four inconspicuous marginal lobes; basal angles broadly rounded; vertical view depressed hexagonal, all angles obtuse to broadly rounded and smooth, apical marginal lobes circularly arranged within the hexagon. Wall smooth and colorless. Length 37–43μ, width 27–29μ, isth. 17–19μ; width of polar lobe 16–17μ. Valle Grande, New Mexico.

This species should be compared with *Euastrum Berlini* Boldt (Boldt 1888) from which it differs in the broader isthmus, more broadly rounded basal angles, and the presence of the apical, marginal lobes.

Cosmarium botrytis var. *mediolaeve* W. West.

Cosmarium costatum Nordst.

Cosmarium cucurbitinum (Biss.) Lütkm.

Cosmarium ellipsoideum var. *minor* Racib.

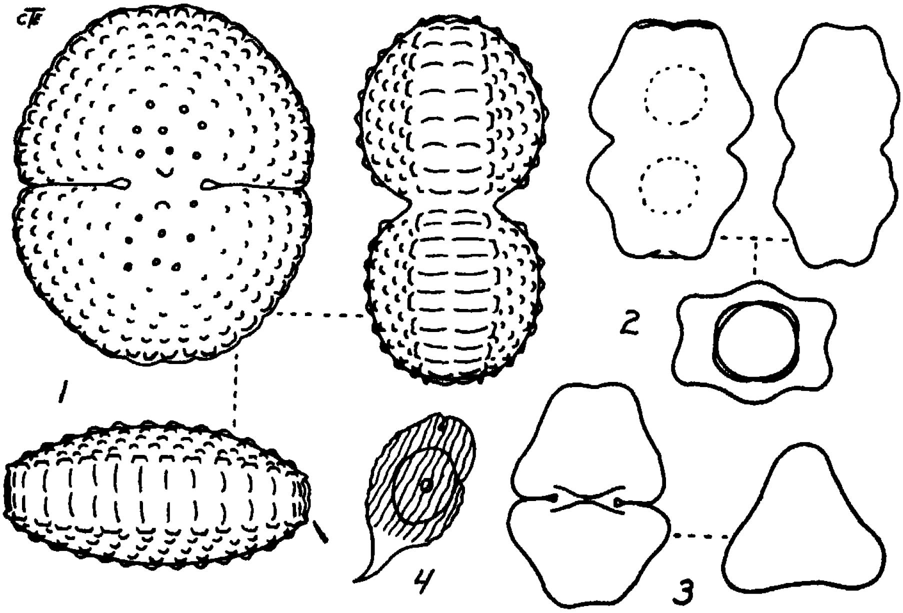

FIG. 1. *Cosmarium vallegrande* Taft, sp. nov.
FIG. 2. *Euastrum notatum* Taft, sp. nov.
FIG. 3. *Staurastrum trihedrale* var. *glabra* Taft.
FIG. 4. *Phacus crenulata* var. *annulata* Taft, var. nov.

Cosmarium holmiense Lund.

The dimensions of the only individual seen were greater than the usual size range. Length 64μ, width 38μ, isth. 19μ.

Cosmarium margaritatum var. *minor* (Boldt.) W. & G. S. West.

Cosmarium meneghinii fa. *reinschii* Istv.

Cosmarium speciosum var. *rostafinskii* fa. *americana* W. & G. S. West.

Cosmarium speciosum var. *simplex* Nordst.

Cosmarium subarctoum (Lager.) Racib.

Cosmarium subcrenatum Hantzsch.

Numerous zygospores were present. The dimensions were: 30–42μ diam. including processes, 27–32μ minus processes.

Cosmarium vallegrande Taft sp. nov. Fig. 1.

Cells about one-fifth longer than broad, deeply constricted, sinus linear, closed; semicells ovate-pyramidate, angles rounded, margins crenate; cell wall granulate, granules arranged in concentric series, smaller at the center and becoming larger near the margin, marginal series of broad, flattened verrucae; vertical view broadly elliptical with slightly flattened ends and having a row of verrucae on either side of the long axis, the intervening space crenulate.

Valle Grande, New Mexico.

Staurastrum polytrichum Perty.

Staurastrum punctulatum Bréb.

Staurastrum punctulatum var. *subproductum* W. & G. S. West.

This variety is identical in shape but slightly larger than *St. punctulatum* Bréb. forma? Boldt (Boldt, 1888). Length 46–48μ, width 40–42μ, isth. 16–17μ.

Staurastrum spongiosum Bréb.

Staurastrum trihedrale var. *glabra* Taft. Fig. 3.

Wolle described *St. trihedrale* as being punctate-granulate. The Oklahoma specimens (Taft, 1930) as well as those from New Mexico have a perfectly smooth wall. While Wolle's figure leaves much to be desired it is still the writer's opinion that these individuals should remain as a variety of his species.

Hydrodictyaceae

Pediastrum boryanum var. *longicorne* Racib.

Oocystaceae

Ankistrodesmus falcatus (Corda) Ralfs.

Nephrocytium limneticum G. M. Smith.

Oocystis lacustris Chodat.

Vaucheriaceae

Vaucheria pachyderma Walz.

Vaucheria sessils (Vauch.) D. C.

CHRYSOPHYTA

Xanthophyceae

Tribonema bombycinum (Ag.) Derbes & Sol.

Ophiocytaceae

Ophiocytium arbusculum (A. Br.) Raben.

Ophiocytium parvulum (Perty) A. Br.

EUGLENOPHYTA

Euglenaceae

Phacus crenulata var. *annulata* Taft var. nov. Fig. 4.

Cell ovoid-pyriform, posteriorly tapering into a sharp-pointed, slightly bent caudus, anterior end broadly rounded and bilobed; flagellum about as long as the cell; margins of the cell crenulate, with one sharp notch; periplast longitudinally striate, lines slightly undulate; paramylon body a single annular disc. Length 31–32μ, width 14–16μ.

Valle Grande, New Mexico.

The variety is distinguished from *P. crenulata* Prescott (1944) by having an annular disc paramylon body, a marginal notch, and a bent caudus.

Trachelomonas granulosa Playf.

Trachelomonas intermedia Dang.

Trachelomonas varians Defl.

Trachelomonas volvocina Ehr.

CYANOPHYTA

Chrococcaceae

Chroococcus turgidus Nag.

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BOOK NOTICE

Rheumatic Fever

In observance of National Heart Week, the Public Affairs Committee, Inc., has issued *Rheumatic Fever—Childhood's Greatest Enemy*, by Herbert Yahraes, the most comprehensive and readable pamphlet yet written on the disease that cripples and destroys more children of school age than any other disease, and that affects more than a million persons, young and old, in the United States.

"This booklet," according to Dr. David D. Rutstein, Medical Director of the American Heart Association, "represents a major step forward in bringing the essential facts concerning rheumatic fever before the American public. Rheumatic fever and rheumatic heart disease constitute one of our country's most pressing public health problems. Science is making progress in combating this disease which takes so many young lives and which attacked more than 40,000 members of the armed forces during World War II. It is the responsibility of every citizen to know the facts about rheumatic fever and to understand the tremendous need for community rheumatic fever programs in order to bring available knowledge within the reach of all sufferers from the disease."

The 32-page, illustrated Public Affairs Pamphlet contains all "the essential facts concerning rheumatic fever" and points to the need for community action on a broad scale. It was prepared by the Public Affairs Committee in cooperation with the American Council on Rheumatic Fever of the American Heart Association in order to provide needed public information on the disease as background for National Heart Week. The United States Junior Chamber of Commerce, the American Legion, Rotary International, Kiwanis International, and other organizations are cooperating in the national effort to stimulate public interest in the problems of heart disease, the greatest cause of death in the United States.

"Diagnosis of rheumatic fever is so difficult and treatment so complex and expensive," the pamphlet declares, "that medical men who have studied the disease most carefully say it can be fought successfully only by a public health program like the one that has been waged successfully against tuberculosis."

"Many different services are needed by the average rheumatic fever family," Mr. Yahraes points out, "and ideally they should be available in every community. They should be brought together by some central agency, perhaps the Department of Health, which would keep a register of cases as they were reported by private and school doctors and by welfare workers, and also a record of all the community facilities that might be of assistance."

"Within the last decade," according to the pamphlet, "considerable progress has been made in working out cooperation between the federal and state governments for financing public programs for the care of RF children. Federal money for that purpose was first set aside in 1939, when Congress authorized the Children's Bureau to include rheumatic children in the crippled children's program. This is financed by the national government under the special grant-in-aid provisions of the Social Security Act."

"The first joint federal-state program—Oklahoma's—was approved by the Children's Bureau in 1940. By 1947 there were twenty such programs, and a dozen others were being planned."

The London County Council's Rheumatism Scheme, which got under way in 1926, is described in the pamphlet as an example of a successful community plan. As a result of this cooperative effort in England by school and health authorities, by private and by public institutions, the incidence of acquired heart disease among London school children dropped from 2 per cent to 0.8 per cent in ten years, and there was a considerable decrease in the number of chronic cardiac invalids. In carrying out this scheme, London provided one hospital bed for every 550 school children. The ratio in New York City is only a fourth or fifth as high.

Rheumatic Fever—Childhood's Greatest Enemy, by Herbert Yahraes, is Pamphlet No. 126 in the series of popular, factual, ten-cent pamphlets issued by the Public Affairs Committee, Inc., non-profit educational organization, at 22 East 38th Street, New York 16, N. Y.

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OBSERVATIONS ON THE INHERITANCE OF SEX IN SCIARA OCELLARIS

(DIPTERA)

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This paper deals with the problem of the inheritance of sex in the fungus fly *Sciara ocellaris*, Comstock. It has been previously shown by Metz and his associates (see Metz, 1929, for a summary of the work) that in *S. coprophila* the females regularly yield "unisexual progenies." That is, the offspring of one female are all or nearly all of one sex, the term "progeny" being used by Metz and in this paper to designate the offspring of a single female. In another species, *S. reynoldsi*, the females regularly yield "bisexual progenies." In this case among the offspring of one female there may be both males and females in various ratios, usually not 1:1. In *S. ocellaris* it was found by them that some females yield unisexual and some bisexual progenies.

In Sciara the sex of the individual is not determined by the kinds of chromosomes in the zygote but by the results of the chromosome elimination which occurs during the early development of the embryo. Cytological and genetic investigations on Sciara by Metz and his co-workers have shown that there are two X chromosomes in the germ line of each sex. Oogenesis is typical and each ovum has one X chromosome. Spermatogenesis is atypical. In the first spermatocyte division a unipolar spindle is formed and the chromosomes of maternal origin go to the pole while those of paternal origin go away from it and are budded off and disintegrate. In the second spermatocyte division, which is bipolar, both halves of the X chromosome go together, precociously, to one pole. The chromosomes which go to the other pole are budded off and lost. The resulting cell is haploid except for two X chromosomes, which are genetically equal, the products of the division of one. Thus all male gametes contain two X chromosomes and all the gametes of any individual male are genetically alike, containing the maternal complement of genes (Metz 1926, 1928, 1929). The fertilized egg is then trisomic, containing three X chromosomes.

The significance of three X chromosomes in the fertilized egg is not clear, for during cleavage the number is reduced to one in the soma of the male, to two in the soma of the female, and to two in the germ-line of both (DuBois 1933, Berry 1939). The eliminated chromosomes are normally paternal in origin. At least one of the genetically-equal paternal X chromosomes is normally eliminated from all cells before the embryo develops. The sex of the individual is determined by the number of X chromosomes remaining in the soma after elimination has taken place. If one remains the individual becomes a male, if two, a female.

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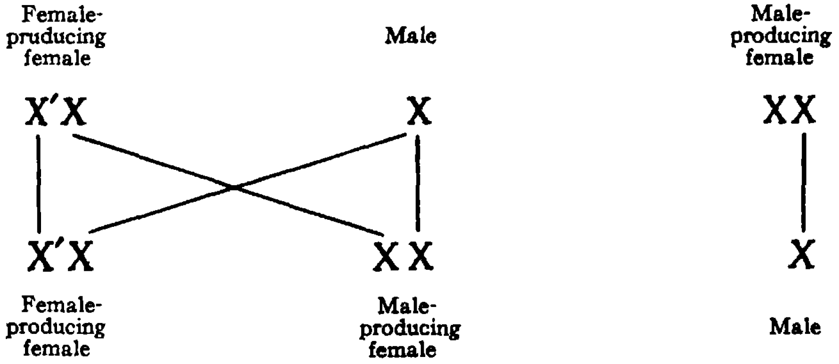
[1] Muellhaupt Scholar, Dept. of Zoölogy and Entomology. Present address, Fishertown, Pennsylvania.

A cytological difference between *S. coprophila* and *S. ocellaris* is the presence of "limited chromosomes" in *S. coprophila* and their absence in *S. ocellaris*. In *S. coprophila* these are limited to the germ-line of both sexes. It has been shown that the limited chromosomes are not sex-determiners (Metz and Ullian, 1929) and they will not be considered further here. Otherwise the two species seem to be alike cytologically.

The X chromosomes have been found to be of two kinds in *S. coprophila* (Metz and Schmuck, 1929, Metz and Smith, 1931) and have been designated X and X' (X prime). The X' chromosome differs from the X in possessing a dominant "prime factor," which is not necessarily a single gene but may be two or more apparently completely linked genes or a segment of the chromosome. No crossing-over has been observed between the X and X'. It has been demonstrated that females carrying the X' chromosome are female-producers. That is, they yield progenies which are entirely of females or nearly so. Females homozygous for the X chromosomes are male-producers. Males from male progenies do not have the X' chromosome. Hence female-producers mated to males of male progenies are expected to yield female-producing and male-producing daughters in a ratio essentially 1:1. The X and X' chromosomes have both been genetically marked. Four recessives have been found on the X and a dominant on the X'.

This may be more easily seen with the aid of a diagram (Fig. 1). The male may be represented by X since it effectively transmits only one.



A female-producing female is heterozygous for the prime factor, and so may be considered digametic. A male-producing female does not have this factor on either of its X chromosomes and so is monogametic. As previously explained, the males get their somatic X from the female parent. Although one of the two X chromosomes in the germ-line of the male is paternal, it is not transmitted.

Although the presence or absence of a prime factor in the female parent determines the sex of the progeny as a whole it does not determine the sex of the individual offspring, for "exceptional" individuals occur. That is, a few females are found in some of the male progenies and a few males occur in some of the female progenies. As expected, the exceptional females are male-producers for they are without the prime factor. It will be presently shown that this condition does not exist in *S. ocellaris*. Here both unisexual and bisexual progenies occur. No prime factor is found and the evidence points toward the conclusion that a number of sex-determining factors affecting the sex ratio are present, some pulling in one direction and some in the other.

MATERIALS

The original flies obtained for this work came from cultures 1688 and 1692 of the laboratory of C. W. Metz. They are from a stock (1255) originally secured by J. P. Reynolds in Alabama. The yellow flies used in the crosses were from the mutant strain discovered by E. G. Lawrence in this laboratory. The genes for yellow body and curled wing are sex-linked recessives and both known to be consistent in expression.

EXPERIMENTAL RESULTS

Tests for the prime factor.

As previously explained, females of *S. coprophila* typically produce unisexual progenies, female or male, depending on whether the female parent is genetically X'X or XX. No crossing over has been found to occur between the X' and X chromosomes and only about .5% has been observed between the two genes on the X. The X' and X chromosomes are both genetically marked in this species. Hundreds of tests carried on over a period of years and all giving consistent results (Metz and Schmuck, 1929a, Metz and Smith, 1931) have shown that females carrying the X' chromosomes are female-producers and those homozygous for the X are male-producers.

TABLE I

SETS OF SIBS WHICH PRODUCED MALE AND FEMALE PROGENIES IN A RATIO HIGHLY SIGNIFICANT IN THEIR VARIANCE FROM A 1:1 RATIO. TEN SETS OUT OF 54 IN THE UNISEXUAL STRAIN AND EIGHT OUT OF 25 IN THE BISEXUAL

	Female Progenies	Male Progenies	Probability
Unisexual strain..	9	26	0092
	0	8	0078
	13	2	0074
	13	2	0074
	35	14	0040
	9	0	.0040
	0	9	.0040
	42	18	0024
	1	13	.0020
	45	5	0000
Bisexual Strain...	19	5	.0064
	2	14	.0040
	13	1	0020
	10	32	.0008
	31	6	.0000
	1	21	.0000
	0	15	.0000
	39	0	.0000

When similar tests are applied to *S. ocellaris* the results obtained are different. There are two sex-linked genes in this species, yellow and curled, both recessive. Recombination between them is about 13%. The yellow gene has been used in the present work.

Yellow females may be either female-producers or male-producers. In this they differ from the females of *S. coprophila*, where a genetic marker designates either an X or X' chromosomes and therefore either a male-producer or a female-producer. Recessives on the X' of *S. coprophila* would not ordinarily show, as females are not X'X'. It appears, therefore, that if a prime factor exists in *S. ocellaris* it is not completely linked with the yellow locus.

On the basis of conditions found in *S. coprophila*, as already outlined, it would be expected that in *S. ocellaris* half the females in female progenies would be female producers (X'X) and the other half male-producers (XX). This assumes that the male parents are derived from male progenies and hence carry only X and not X'. Exceptional males from female progenies are not used because of the possibility of some of them carrying an X' chromosome. This expectation is not realized in *S. ocellaris*. Among sisters in this species the ratio of female-producers to male-producers is frequently far from 1:1. Out of 54 sets of sisters from unisexual stock in which eight or more sisters were tested in each set, the divergence from a 1:1 ratio was highly significant in ten sets. That is, in these cases the probability of getting the ratio obtained by chance when a 1:1 ratio was expected was less than one chance in a hundred. Out of a sample of 54 it would not be very uncommon to get by chance a case which would by this definition be highly significant, but to get ten out of 54 is not within the realm of probability. Similarly in 25 such sets in bisexual stock there were eight cases in which the divergence from a 1:1 ratio was highly significant. The counts and respective probabilities are given in Table I. It is to be noted from the table that in some cases the probability is far below .01 and that in some others the size of the sample is rather small and might have produced a still more significant variation from the 1:1 ratio had the sample been larger. These sets of sisters were not among those tested for the prime factor with genetic markers nor were they from the female-producing line mentioned later.

TABLE II

FEMALE-PRODUCERS AND MALE-PRODUCERS IN PROGENIES WHERE AN EFFORT WAS MADE TO MATE ALL SISTERS

Females in Progeny	Female-Producers	Male-Producers	Probability on Basis of 1:1	Percent of Females Giving Progenies
77	25	28	7948	69
82	34	30	.7082	68
106	33	38	.6350	67
56	26	20	4616	82
99	47	38	3858	86
60	30	20	.2024	83
88	47	31	.0888	89
69	42	18	0024	87
71	45	5	0000	70

In bisexual progenies there is a tendency for males to hatch earlier than females. If, similarly, there is a tendency for one type of female to hatch before the other, a skew ratio might be obtained when none in fact existed provided females hatching first were mated and those hatching later discarded. This, however, appears not to be the case for the following reasons: (1) As will be seen in Table I, among the unisexual lines which gave highly significant skew ratios six were predominantly female and four predominantly male, and in the bisexual line four were female and four male. If there had been an unintentional selection of females hatching early or late the skew ratios would be expected to be predominantly all of the same sex. (2) When the date of hatching of each female was recorded the results indicated no tendency for one type of females to hatch earlier than the other. (3) When all the females of a progeny were mated and a skew ratio obtained there could be no selection except selective mortality or sterility. Table II shows results where an effort was made to obtain offspring from each female in a progeny, with better than 60% yield. In two progenies out of nine a highly significant skew ratio occurred.

From the evidence presented it is concluded that ratios differing from 1:1 as to female-producers and male-producers do occur in female progenies in this species.

Test for the prime factor with genetic markers.

The recessive sex-linked gene yellow in *S. ocellaris* may be used to test directly whether there is a prime factor on an X chromosome determining the sex of progeny as there is in *S. coprophila.*

If a female progeny is obtained from a homozygous wild-type female by a yellow male, the female offspring are wild-type in color and heterozygous for yellow. If a prime factor operates as in *S. coprophila*, it should be derived in this case from the wild-type mother. If the F_1 females are mated to yellow males some of their daughters will be wild-type and some yellow, and except for cases involving crossing-over the wild-type daughters should be female-producers and the yellow ones male-producers. This is represented diagrammatically in Fig. 2 below, where $^+$ stands for wild-type and y for yellow. A male is represented by only one gene as a male effectively transmits only one X chromosome. Fig. 3 shows the crosses which would yield the opposite condition, in which wild-type daughters should be male-producers and yellow daughters female-producers.

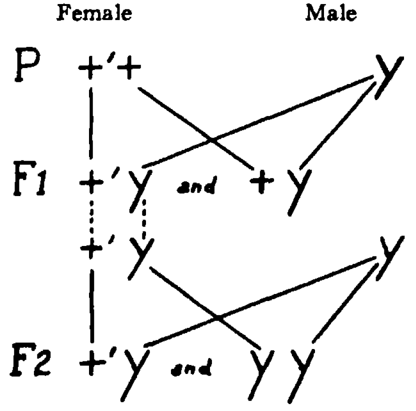


Fig. 2

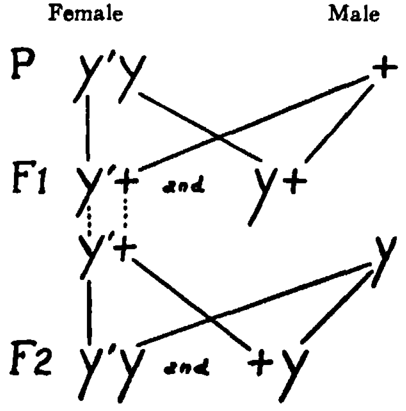


Fig. 3

Crosses of the first type yielded from three progenies, 73 wild-type F_2 females, all expected to be female-producers. Actually, 38 proved to be female-producers and 35 to be male-producers. Eighty-two of their yellow sisters, expected to be male-producers, included instead, 47 female-producers and 35 male-producers. Neither 38 to 35 nor 47 to 35 is significantly different from a 1:1 ratio, and from these figures to postulate a prime factor one would need to assume 50% crossing over or non-linkage.

In the second cross 173 females, of which 90 were wild-type and 83 yellow, were secured from five progenies. They produced progenies as follows: Of the 90 wild-type females expected to be male-producers, 60 were female-producers and 30 male-producers, which is a highly significant variation from the 1:1 ratio. Of their 83 yellow sisters, which were expected to be female-producers, 41 were female-producers and 42 were male-producers, a 1:1 ratio. Yellow females of another progeny, of which no wild-type sibs were saved, turned out to be 3 female-producers and 17 male-producers. This is a highly significant variation from the 1:1 ratio and in the direction opposite from the expected.

These data make it clear that there is no prime factor on the X chromosome acting as a unit as in *S. coprophila* and linked either completely or incompletely with yellow, nor is there a unit autosomal prime factor showing independent assortment with yellow. These results are given in Table III.

TABLE III

SHOWING THAT A "PRIME FACTOR" OPERATING AS IN *S. coprophila* IS NOT ACTING IN THIS SPECIES. IF IT WERE, IN THE FIRST CROSS THE WILD-TYPE SIBS WOULD ALL BE FEMALE-PRODUCERS AND THE YELLOW ONES ALL MALE-PRODUCERS, WHILE IN THE SECOND CROSS THE RESULT WOULD BE JUST THE OPPOSITE

Parent Culture	Wild-Type Sisters		Yellow Sisters	
	Female-Producers	Male-Producers	Female-Producers	Male-Producers
First cross (figure one)				
AKI..........	6	6	17	4
BDZ	19	17	11	11
BEA.. ..	13	12	19	20
Total	38	35	47	35
Second cross (figure two)				
FY	4	2	7	2
HX . ..	4	5	3	5
HY . .	7	0	3	7
AUB.... . .	20	10	9	10
AUD.	25	13	19	18
Total... ..	60	30	41	42
GCM	.	....	3	17

Evidence from a female-producing line.

It was found by Metz and Schmuck (1929b) that female-producing females of *S. coprophila* could have X' sons, which when mated to female-producing females would yield some X'X' females. The daughters of such females are all female-producers and their exceptional sons carry and transmit the X' chromosome. By continually mating females to their exceptional brothers, only female-producers should be obtained, no matter how many generations this be carried on.

A female-producing line of *S. ocellaris* was obtained from a female caught in one of the government greenhouses in Washington, D. C. For three inbred generations all females tested were female-producers. As there were 129 of these, with an average of 75 offspring per female, the results cannot possibly be attributed to chance.

Lest a misunderstanding arise it should be explained that in the inbred female-producing line not all females tested were mated to their brothers, as there were not sufficient exceptional males to do this. The exceptional males were mated to as many of their sisters as possible to produce inbred lines and the rest of the females were mated to other males to ascertain whether or not they were female-producers. It has been shown by Metz that in *S. coprophila* the male parent does not affect the sex of the immediate progeny. It may be noted that if there were any effect it would probably tend to prevent rather than bring about the result here obtained, since the other males were not from female-producing lines.

Thus if there were a single prime factor operating, all future inbreeding should yield only female progenies. This was not the case. By selecting females from progenies in which there were fewer exceptional males the female strain was maintained, while at the same time selecting females from progenies in which there were more exceptional males a large proportion of male progenies was obtained after a few generations. These results are summarized in Table IV. Apparently male-producers were obtained by chance combinations of factors for male-production or lack of female-production. It should be possible to obtain a stable female-producing strain by continued selection until flies are obtained which are homozygous for the factors which make for female-production.

TABLE IV

RESULTS OF SELECTION IN A MALE DIRECTION IN A FEMALE-PRODUCING LINE, BEGINNING AT THE SEVENTH GENERATION. EACH NUMBER REPRESENTS THAT MANY PROGENIES. THEY ARE DIVIDED INTO GROUPS CORRESPONDING TO THE PER CENT OF THE MINORITY SEX IN THE PROGENY

	FEMALE PROGENIES					MALE PROGENIES				
	0–9	10–19	20–29	30–39	40–49	40–49	30–39	20–29	10–19	9–0
First generation	1	0	0	0	0	0	0	0	0	0
Second generation	4	6	4	3	4	3	2	4	4	2
Third generation	12	25	17	13	7	10	3	2	3	0
Fourth generation	46	10	2	0	0	0	0	0	0	0
Fifth generation	14	10	8	0	0	0	0	0	0	0
Sixth generation	38	5	0	0	0	0	0	0	0	0
Seventh generation	55	24	12	5	2	1	1	0	0	0
Female line	9	2	1	1	0	0	0	0	0	0
Male line	10	5	2	0	1	0	1	0	0	0
Eighth generation										
Female line	8	3	0	0	0	0	0	0	0	0
Male line	1	4	2	0	0	6	2	3	4	4
Ninth generation										
Female line	28	6	0	0	1	0	0	0	0	0
Male line	7	1	2	1	4	2	0	2	2	7
Tenth generation										
Female line	46	22	6	1	2	0	0	0	0	0
Male line	0	1	1	1	1	8	6	8	7	12
Three sets tested for the prime factor. See text and figure 4.										
Wild-type females	1	3	8	7	5	4	1	0	0	7
	1	1	6	8	5	1	3	0	0	7
	0	3	4	7	3	1	0	1	0	2
Total for wild-type females	2	7	18	22	13	6	4	1	0	16
Yellow females	1	1	0	2	1	3	0	2	0	22
	0	0	3	2	2	2	1	0	0	21
	0	1	0	2	2	0	0	0	0	6
Total for yellow females	1	2	3	6	5	5	1	2	0	49
Total for wild-type and yellow females	3	9	21	28	18	11	5	3	0	65

At the same time a male-producing line was obtained from the same original female from which the female-producing line mentioned above was obtained. This line was essentially bisexual and so differed from a male-producing line in *S. coprophila*, which could only be obtained by mating exceptional females (which are without the prime factor) to their brothers. Out of 105 females tested during six generations, all but three produced more males than females. Of these three, two produced only one more female than males and the other produced two more females than males.

The female-producing females were also outcrossed to yellow so as to mark the X chromosome. If a single prime factor were located on this chromosome without crossing over, the result should be as follows (Fig. 4) when the first generation females are backcrossed to yellow.

The wild-type females are all expected to be female-producers and the yellow females are expected to be male-producers. The results may be seen in Table IV, a number of the progenies were bisexual, especially from the wild-type females.

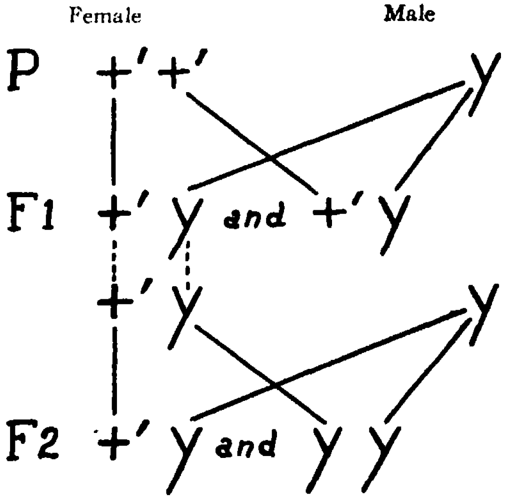


Fig. 4

The line dividing progenies between the categories predominantly male and predominantly female appears to divide the progenies arbitrarily and the natural division falls between the unisexual male progenies on the one hand and all the others. This is even more striking than the table indicates, for of the 65 unisexual male progenies two had one exceptional female each and all the others, with an average of 102 flies each, were all males with no exceptional females.

If the unisexual male progenies are considered as the expected male progenies and all the others as the expected female progenies, the results for the wild-type females are, 75 non-crossovers and 16 crossovers, and for the yellow females, 49 non-crossovers and 25 crossovers. If these numbers are set in a two-by-two table it is found that chi-square is 5.37, which is significant, though not highly significant. The results, therefore, do not preclude the possibility that a factor linked with the locus of yellow and crossing over with it is operating here and determining a bisexual and unisexual condition.

Bisexual females from the strain just considered seem to have three X chromosomes in their germ-line instead of two, a condition observed by Reynolds (1938) in a bisexual strain of *S. coprophila*. He found that some of the ova get two X chromosomes and some get one, in oogenesis. The former become females and the latter males. This does not involve the X′ chromosome and in returning to the normal condition the females all were male-producers.

The evidence that the three-X condition existed in this line is as follows: (1) Wild-type and yellow females were produced in some crosses between wild-type females and wild-type males. Ordinarily yellow females are never found in progenies resulting from such crosses because a wild-type male transmits only the X chromosome bearing the wild-type gene. This is so because in the developing male the two X chromosomes of paternal origin in the trisomic zygote are eliminated in the somatic tissue and one is eliminated in the germ-line. Later, when germ cells are formed, all the chromosomes of paternal origin are lost in the first spermatocyte division, as previously explained. (2) Yellow females from the cross just described mated to yellow males yielded wild-type and yellow males and females. Ordinarily in crosses of yellow by yellow the offspring are all yellow, as any fly which could transmit the wild-type gene would manifest it phenotypically. (3) That such females have in their germ-line three X chromosomes rather than being heterozygous and having two is further indicated by the ratio of the offspring. Heterozygous females mated to yellow males produce wild-type and yellow offspring in a ratio close to 1:1. But if a female has two X chromosomes bearing yellow and one bearing wild-type, it is to be expected that twice as many female offspring will be wild-type as yellow and twice as many male offspring will be yellow as wild-type. In general this proportion was realized in these cases but

TABLE V

Showing the Dispersion on a Maleness-femaleness Scale of the Progenies of Four Groups of Closely Related Females. It is to Be Noticed that the Pattern Is Similar for Female-producers and Similar for Male-producers in Each Group, Regardless of the Sex-linked Phenotype, but Different When Female-producers Are Compared with Male-producers. The Numbers Stand for Progenies, Not Individual Flies

	Individuals of Minority Sex per 100 of Majority Sex										
	0	1–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99
I. Wild-type female-producers	0	2	3	6	15	9	12	4	5	6	0
Yellow female-producers	0	2	1	1	2	2	2	3	1	1	2
Wild-type male-producers	16	0	0	0	1	0	3	2	1	3	1
Yellow male-producers	47	2	0	0	2	0	0	1	2	3	0
II. Wild-type female-producers	0	9	6	2	2	0	0	0	0	0	1
Yellow female-producers	0	4	2	2	1	0	0	0	0	0	1
Wild-type male-producers	16	1	0	0	0	0	0	0	0	0	1
Yellow male-producers	10	1	0	0	0	0	0	0	0	0	0
III. Wild-type female-producers	5	8	0	0	0	0	0	0	0	0	0
Yellow female-producers	6	13	0	0	0	1	0	0	0	0	0
Wild-type male-producers	0	3	0	2	6	4	1	0	1	0	0
Yellow male-producers	1	6	6	4	2	2	0	0	0	0	0
IV. Wild-type female-producers	4	8	2	1	1	1	1	0	0	0	0
Yellow female-producers	4	11	0	1	0	1	1	0	0	1	0
Wild-type male-producers	12	2	1	1	0	0	0	0	0	0	0
Yellow male-producers	9	3	0	0	0	0	0	0	0	0	0

sometimes the ratio was still farther from 1:1 than expected, indicating a tendency for the yellow chromosomes to segregate more frequently than would be expected by chance.

It may be seen from the entries in Table IV under the sets tested for the prime factor, and still more clearly in Table V, that the distribution pattern is similar for the wild-type and yellow female-producers and similar for the wild-type and yellow male-producers, but is different in the female-producers as compared with the male-producers. Each number represents that many progenies and in Table V they are arranged in columns by the number of individuals of the minority sex in each progeny per hundred of the majority sex. The first four rows are the same as the totals for the three sets tested for the prime factor entered in Table IV. This indicates some factor independent of the X chromosome but associated with the determination of sex of progeny which determines, within certain limits, whether the progeny is unisexual or bisexual.

TABLE VI

THE PROGENIES OF SISTER FLIES, GROUPED TO SHOW THEIR DISTRIBUTION ON A MALENESS-FEMALENESS SCALE. THE NUMBERS REPRESENT PROGENIES, NOT INDIVIDUALS. THEY ARE ARRANGED IN COLUMNS ACCORDING TO THE PER CENT OF THE MINORITY SEX IN EACH PROGENY. EACH ROW REPRESENTS A SET OF PROGENIES FROM SISTERS, AND THE SETS ARE ARRANGED IN ORDER, BEGINNING WITH THOSE HAVING THE MOST FEMALE PROGENIES

PERCENT FEMALES					PERCENT MALES					TOTALS	
0-9	10-19	20-29	30-39	40-49	40-49	30-39	20-29	10-19	0-9	♀ Progenies	♂ Progenies
11	13	9	2	4	0	0	0	0	0	39	0
5	6	5	7	8	3	2	0	1	0	31	6
0	6	1	4	8	1	2	1	0	1	19	5
1	1	2	4	3	3	1	0	1	0	11	5
3	4	3	1	2	5	0	0	1	0	13	6
0	1	5	6	5	3	4	1	0	0	16	8
0	3	7	8	7	6	5	2	0	0	25	13
0	0	4	5	3	4	0	4	0	0	12	8
2	2	3	2	3	5	2	1	2	0	12	10
0	0	1	6	0	1	1	3	1	0	7	6
0	0	4	6	2	4	4	2	1	0	12	11
0	3	0	0	4	2	3	1	2	0	7	8
1	1	4	7	7	6	7	6	4	1	20	24
0	1	1	2	5	4	3	4	3	0	9	14
0	1	2	1	1	3	1	2	4	2	5	12
0	1	0	2	2	5	5	1	2	0	5	13
0	0	2	5	3	10	4	9	6	3	10	32
0	0	0	3	0	0	1	3	5	1	3	10
0	0	0	1	1	1	0	7	6	0	2	14
0	0	0	0	1	0	2	3	6	2	1	13
0	0	0	1	0	4	8	7	1	1	1	21
0	0	0	0	0	2	3	4	4	2	0	15

Totals of the three groups respectively.

19	33	33	38	41	26	13	9	2	1	166	51
3	6	12	21	16	18	17	13	11	1	58	59
0	3	5	15	13	29	27	40	37	11	36	144

It will be seen in Table IV under the three sets tested for the prime factor and the totals given there that the distribution is bimodal. In unisexual lines the distribution is strictly bimodal, with the female progenies at one end of the distribution and the male progenies at the other. In some bisexual sets the distribution of the progenies of sisters has a single mode. The number of progenies with more females and the number with more males frequently are not in a 1:1 ratio. This is shown in Table VI, where twenty-two closely related sets of progenies are tabulated. It will be seen that the progenies of sisters tend to group together when arranged on a scale of femaleness and maleness and when one sex predominates there is a tendency for more progenies of that sex to be unisexual than for progenies of the other sex.

Some crosses have been made between unisexual and bisexual lines and the first generation females tested to find out what kind of progenies they yield, but much remains to be done. As may be seen in Table VI, there are frequently some unisexual progenies in a bisexual line and the distribution of the progenies forms a curve with a mode somewhere near the center and with the ends tapering off. Females from unisexual progenies derived from a bisexual line may yield bisexual progenies, though a continued selection for unisexual progenies would probably after a time yield a stable unisexual line.

TABLE VII

THE RESULTS OF SOME CROSSES BETWEEN UNISEXUAL AND BISEXUAL STRAINS

Parentage of First Generation	Number of First Gen. ♀ ♀ Tested	Nature of Second Gen. Progenies	Exceptionals per 100 of Others
♀ unisexual, ♂ unisexual	86	Unisexual	1 2
♀ unisexual, ♂ bisexual	69	Unisexual	1 3
♀ unisexual, ♂ bisexual	53	Some unisexual, some bisexual	15.7
♀ unisexual, ♂ bisexual	91	Bisexual	58 3
♀ bisexual, ♂ unisexual	44	Some unisexual, some bisexual	9.5
♀ bisexual, ♂ bisexual	102	Some unisexual, some bisexual	32 0

In Table VII is presented the results of several crosses. The unisexual progenies mentioned here are all from stable unisexual lines. The variation in results, the fact that unisexual progenies from a bisexual source are not stable, and the grouping of the progenies of sisters about a mode which is not the same for different sets of sisters, indicate the presence of more than one factor and its allele determining the sex ratio of the progenies.

DISCUSSION

There are three different problems in the determination of sex in Sciara: (1) the determination of the sex of the individual, (2) the determination of the sex of progenies, and (3) the determination of the sex of groups of closely related progenies, such as the progenies of sisters.

The determination of the sex of individuals by the elimination of chromosomes has already been discussed at length. Gynanders are not uncommon in *S. ocellaris*. The division is usually roughly with the longitudinal axis of the body. When the female parts are wild type and the male parts are yellow they may be readily distinguished and much variation in pattern is observed among individuals.

To discover whether a sex-linked "prime factor" similar to that in *S. coprophila* occurs in *S. ocellaris*, three types of crosses were made, each of which would reveal the presence of such a factor. The results expected on the assumption of this factor were not realized in any of the crosses. In some cases the number of female-producers was essentially the same as the number of male-producers among sisters which were all expected to be male-producers, and vice versa. In some cases skew ratios were obtained, which occurred in the direction opposite to the expected as well as in the expected.

In keeping stock cultures of *S. ocellaris* one of the difficulties encountered is that a line may at any time "go male" or "go female" so that it becomes difficult to provide for the next generation. If a single factor were operating to determine the sex of progeny, male and female progenies should be produced each generation in essentially equal numbers. Also a female-producing line would remain such as long as inbred with exceptional males instead of becoming male after a few generations of selection.

Skew ratios sometimes occur in the inheritance of the X chromosome from heterozygous females, but this cannot be related to the skew ratios of sex of progeny, for it is far less frequent and a much larger sized sample is necessary to detect it.

There may be a marked similarity in the distribution on a maleness-femaleness scale among progenies of the female-producers of both phenotypes and among the male-producers of both phenotypes, while no such similarity is found when the female-producers are compared with the male-producers (Table V). From this it appears that a factor or factors determining the distribution of progenies is associated with the determination of sex of progeny, and seems to be autosomal since it is independent of the sex-linked phenotypes.

In other cases sisters of one phenotype produced male and female progenies in a ratio significantly skew while their sisters yielded male and female progenies in a ratio of 1:1 (Table III, AKI, AUB, AUD). In each case the size of the sample was not great enough to show the two sets of data significantly different from each other in a two-by-two table. If the difference is real, its cause seems to be a sex-linked factor.

Where the sex of progenies is distributed along a scale from unisexual to bisexual, the dividing point between these two groups becomes arbitrary. In such cases progenies were called bisexual if there were ten or more individuals of the minority sex per hundred of the majority sex, for in unisexual strains the ratio of exceptionals does not ordinarily exceed this.

The age of the female parent appears to make no difference in the sex of progeny, as no significant difference was observed among progenies of the second generation from females mated when less than eight hours old and females mated when over one hundred twenty-three hours old. These lines were closely related, as the females tested were sisters and they were mated to brothers.

External environment also seems to be eliminated as a factor in these results. No tests were made to ascertain this, but cultures were kept together on the same table and frequently some groups of sisters would be yielding bisexual progenies at the same time that others were yielding unisexual progenies, and some groups of progenies would be predominantly male at the same time that others were predominantly female.

From the facts obtained in the present study it is concluded that sex of progeny in *S. ocellaris* is determined by a number of factors, predominantly autosomal, though some may be sex-linked. It is certain that a determiner acting as a unit like the prime factor in *S. coprophila* does not exist in *S. ocellaris*, at least in the strains thus far studied. To ascertain more definitely where these determiners are it is desirable or necessary to have a number of autosomal markers and viable deletions.

Since no crossing over has been observed in *S. coprophila* between the X and X' chromosomes, though there are two markers on each, there is a possibility that the prime factor actually is multiple in this species also and spread over the X' chromosome. A transition from one species to the other, accompanied by translocations, could cause such a multiple factor on one chromosome to become scattered on other chromosomes. On this hypothesis, *S. coprophila* would be the older species. In the contrary case, a concentration of factors on one chromosome by translocations from others would be implied, which seems less likely.

SUMMARY

1. *Sciara ocellaris* produces both unisexual and bisexual progenies, in contrast to *S. coprophila*, which typically produces only unisexual progenies. In *S. ocellaris* some unisexual strains are stable. Apparently all bisexual strains are unstable, for if a number of sisters are tested some yield unisexual progenies and some bisexual. The distinction between these two types of progenies is not always clear, for there may be a complete series from unisexual progenies to those in which males and females are present in a ratio of 1.1. Females of unisexual progenies from a bisexual source may yield bisexual progenies.
2. From the results of three kinds of crosses it is shown that the sex of progeny is not determined by the presence or absence of a single sex-linked "prime factor," as it is in *S. coprophila*. In no case were the results expected on this assumption realized.
3. It is shown that no single autosomal "prime factor" exists in this species. By selecting less strongly female progenies of a female-producing line, male progenies were obtained after several generations, while selecting for the more strongly female progenies continued a female-producing strain. On the assumption of a single autosomal factor, the strain would be homozygous and no amount of selection would affect it.
4. Evidence that a sex-linked factor or factors may be operating is given in that male and female progenies of sisters of one sex-linked phenotype may occur in a skew ratio while the progenies of their sisters of the other phenotype occur in a 1:1 ratio.
5. Also there is evidence of autosomal factors, since the distribution on a maleness-femaleness scale may be strikingly similar for progenies of female-producing and male-producing sisters of both phenotypes, but dissimilar (not mirror-image distributions) when the male-producing and female-producing sisters are compared.
6. Female-producers heterozygous for a single "prime factor" should yield female-producing and male-producing females in essentially equal numbers. However, a number of ratios occur which differ significantly from a 1:1 ratio, and seem to be free of any accidental selection.
7. These results do not appear to have been influenced by external or internal environment.

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Ageing and Degenerative Diseases

Are you growing old and fat, and reading the papers telling of your good friend passing on? While you're reflecting on whether you may be next, why not read this good book on our accumulating knowledge and widespread ignorance of ageing? Thirteen authors contributed their clinical or experimental experience at a symposium on the processes of ageing and diseases of older persons in St. Louis, March 24, 25, 1944.

W. C. Hueper wrote a carefully organized summary of the last fifty years' contributions to the relationships of physical and chemical agents of endogenous and exogenous origin to the histopathological changes of the large and small blood vessels, with interesting side remarks on their regional anatomical localization. Two tables give full data on the etiological factors and the anatomical types of spontaneous and experimental arteriosclerosis. Well documented by American and foreign literature the anoxemic causative mechanisms are considered equally in small animal and human observations, with frequent references to clinical diseases and with implications of their import to future clinical research, prophylaxis and treatment.

Irvig H. Page presented a very readable series of questions and answers on arteriosclerosis and lipid metabolism, terminating in the final query—How can the known factors which predispose to atherosclerosis be controlled? Stimulating to the clinician and inquisitor alike is the conclusion: "First prevention of hyperlipemia, second, prevention of the mechanical strain, and third, prevention of that state of the tissues in the arterial walls which increases the receptivity to plasma lipids or prevention of that state of the blood which leads to abnormal precipitability of its lipids."

William B. Kountz outlined the early trial and error methods in the St. Louis City Infirmary resulting in the conclusion that clinical study of degeneration must focus on the functional ability of the body. His coworkers gave two clinical investigations. One was a study of 212 aged patients to relate age, sex, basal metabolic rate, cardiac decompensation and coronary and peripheral sclerosis to blood cholesterol levels, with the conclusion that there was no relation of blood cholerterol to the degree of atherosclerosis. The other study concluded that with increasing age, there is a gradual lowering of glucose tolerance but not to a degree that could be considered diabetic.

The Pediatrics department presented a case of progeria (premature senility).

Lester R. Dragstedt reported observations suggesting that the factors responsible for the primary deposition of lipids in the intima may be similar to those producing such deposits in the liver. As Lipocaic fat-free alcohol extract of the pancreas) prevents the deposition of fat in the liver.

Edward J. Stieglitz emphasized the factors obstructing diagnosis (tentative opinions): (1) difficulties inherent in the disease, (2) difficulties inherent in the patient, (3) inadequacy of clinical methods, and (4) complexities of diagnoses per se.

Wm. J. Kerr offered a challenge to the adequate therapeutic management now available in obesity, postural defects, pulmonary emphysema and circulatory failure. Wm. MacNider predicted that the research of the future would be increasingly of a biochemical and biophysical order.

John A. Saxton, Jr., reported the experiments of McCay et al. indicating that the life span of rats can be extended 50 per cent by drastic reduction of caloric intake from early life. Also, the incidence of tumors, nephrosis, chronic pneumonia, middle ear disease and gastrointestinal lesions are less. Implications in man are suggested.

Leo Loeb, discussing cancer and the processes of ageing, concluded the necessity of an accumulation of stimuli of a certain kind and range of intensity, acting over a continuous length of time on a given tissue, which has been sensitized by genetic factors specific for each tissue, organ, individual and species. Observations on Mammary carcinoma of mice illustrated the genetic principles.

A final round table discussion made one realise the flux and infancy of our knowledge of ageing, a growing problem of our century.—*Grant O. Graves, M. D.*

Ageing and Degenerative Diseases, Volume XI of the Biological Symposia Series. Jaques Cattell Press, Lancaster, Pa. 1945.

THE CHEMISTRY OF ELEMENTS 93, 94, 95 AND 96 (NEPTUNIUM, PLUTONIUM, AMERICIUM AND CURIUM)

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Four new elements have been added to the list of 92 elements in the last six years. All of these were made artificially; one of them, plutonium (Pu^{239}) has since been discovered in uranium-bearing ore at a concentration of about 1 part in 10^{14}. These elements are known as elements 93, 94, 95 and 96 or as neptunium, (Np), plutonium, (Pu), americium, (Am), and curium, (Cm).

The method of preparation of these elements by means of nuclear transformations together with other facts about them are given in Table I.

Of interest among these isotopes are ${}_{93}\mathrm{Np}^{237}$ and ${}_{94}\mathrm{Pu}^{238}$; these isotopes have long half-lives which make them useful for the determination of many of their chemical properties. Such properties were determined with very minute amounts of these elements by tracer techniques and special micro methods.

Also of interest is ${}_{94}\mathrm{Pu}^{239}$ because of its long half-life and the fact that it captures show neutrons to fission and hence serve as a useful source of atomic energy. ${}_{93}\mathrm{Np}^{239}$ is of interest because it is the intermediate formed in the process of nuclear transmutation of ${}_{92}\mathrm{U}^{238}$ to ${}_{94}\mathrm{Pu}^{239}$.

The first pure compound of an artificially-made element that was ever isolated in weighable quantity was that of plutonium (${}_{94}\mathrm{Pu}^{239}$) in 1942; now relatively large quantities are available.

NAMES OF THE ELEMENTS

The names of elements 93, 94, 95 and 96 were chosen for the following reasons:

Neptunium and plutonium are the elements that appear immediately after uranium and are named for the planets in similar order. Americium (${}_{95}\mathrm{Am}$) is named for the Americas. It has six 5f electrons and is similar to Europium (${}_{63}\mathrm{Eu}$) which has six 4f electrons and named for Europe. Curium (${}_{96}\mathrm{Cm}$) is named after the Curies who did the early work on the radioactive elements. It has seven 5f electrons and is similar to gadolinium (${}_{64}\mathrm{Gd}$) which has seven 4f electrons and was named after Gadolin who did much of the early work on the rare earths.

CHEMICAL PROPERTIES

Previous to 1940 only a very scant amount of data were available on the chemical properties of the heavy elements. With the discovery of the transuranium elements there was a renewed interest in determining the chemical properties of the heavy elements and their compounds which are employed in the tracer and carrier techniques used in determining properties of extremely small quantities of radioactive material; these properties also aided in the classification of the transuranium elements. Particularly was it necessary to determine the chemistry of plutonium and neptunium very completely because of requirements for separation and purification of ${}_{94}\mathrm{Pu}^{239}$ from the other materials in uranium piles. As a result of this it is now stated that the chemistry of plutonium is as well or better understood than that of most of the elements in the periodic system. However, most of this information is not yet available for publication.

TABLE I

ISOTOPE	DISCOVERY		HOW MADE	EMITS	HALF-LIFE
	Date	By Whom			
$_{93}Np^{239}$	1940	McMillan and Abelson	$U^{238} + n \longrightarrow U^{239}$ (23 min) $\downarrow$ $Np^{239} + \beta$	β	2.3 days
$_{93}Np^{237}$	1942	Wahl and Seaborg	$_{92}U^{238} + n \longrightarrow {}_{92}U^{237} + 2n$ (7 days) $\downarrow$ $_{93}Np^{237} + \beta$	α	2.25×10^6 years
$_{94}Pu^{238}$	1940	Seaborg, McMillan, Wahl and Kennedy	$U^{238} + {}_1H^2 \longrightarrow Pu^{238} - 2n$	α	50 years
$_{94}Pu^{239}$ (fissionable)	1941	Seaborg, Segre, Kennedy and Lawrence	$_{93}Np^{239} \longrightarrow {}_{94}Pu^{239} + \beta$	α	24,000 years
$_{95}Am^{241}$	1944	Seaborg, James, Morgan	$_{92}U^{238} + \alpha \longrightarrow {}_{94}Pu^{241} + n$ $\downarrow$ $_{95}Am^{241} + \beta$	α	500 years
$_{95}Am^{242}$			$_{95}Am^{241} + n \longrightarrow {}_{95}Am^{242} + \gamma$	β	18 hours
$_{96}Cm^{242}$	1944	Seaborg, James and Ghiorso	$Pu^{239} + \alpha \longrightarrow {}_{96}Cm^{242} + n$	α	5 months
$_{96}Cm^{242}$			$_{95}Am^{242} \longrightarrow {}_{96}Cm^{242} + \beta$	α	5 months
$_{96}Cm^{240}$			$_{94}Pu^{239} + \alpha \longrightarrow {}_{96}Cm^{240} + 3n$	α	1 month

Legend: n = neutrons.
α = alpha particles.
β = beta particles.
γ = gamma ray.
subscript = atomic number.
superscript = atomic weight.

Neptunium has valence states of 3, 4, 5 and 6. This is somewhat comparable to uranium which has valence states of 3, 4 and 6. Greater oxidizing power is required to oxidize neptunium to its higher state than is required for the higher state of uranium.

Plutonium likewise has valence states of 3, 4, 5 and 6 and still greater oxidizing power is required to convert it to its higher state.

The stability of the valence state of 3 increases from uranium to plutonium and it would be predicted that the maximum stability would probably be obtained with curium (element 96) which has seven 5f electrons.

This prediction is verified by data which now indicate that americium and curium probably exist in aqueous solutions in the oxidation state of 3 only.

Curium is the only one of these four elements that has not been prepared in the form of a pure compound.

All of these new elements are strong alpha particle emitters except Np^{237}; consequently Np^{237} is the only one with which it is relatively safe to work in the laboratory without special precautions to avoid health hazards. Cm^{242} has 10^{14} alpha disintegrations per minute per milligram.

The known properties of these transuranium elements make possible a suggested classification of these elements in terms of a new series similar to the rare earth series. This requires a correction of the older classification of elements 89, 90, 91 and 92 which are actinium, thorium, protactinium and uranium. The meager knowledge of the chemical properties of these four elements (89, 90, 91 and 92) indicated that the 6d electron shell was filling in the following manner.

OLD CLASSIFICATION OF ELECTRON ORBITS

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	*6d*	7s
89	Ac	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*1*	2
90	Th	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*2*	2
91	Pa	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*3*	2
92	U	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*4*	2

If old classification had been correct then the following would be true:

93	Np	(orbits same as above)	*5*	2
94	Pu		*6*	2
95	Am		*7*	2
96	Cm		*8*	2

This would have made neptunium and plutonium similar to $_{75}$Re and $_{76}$Os and to elements 43 and 44 whose electronic configurations are

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	*4d*	4f	5s	5p	*5d*	5f	6s	6p	6d	7s
43	Ma	2	2	6	2	6	10	2	6	*5*		2							
44	Ru	2	2	6	2	6	10	2	6	*6*		2							
75	Re	2	2	6	2	6	10	2	6	10	14	2	6	*5*		2			
76	Os	2	2	6	2	6	10	2	6	10	14	2	6	*6*		2			

But they were found *not* to resemble these elements. This has led Seaborg to suggest that the 5f shell (level) is filling instead of the 6d shell (level). The energy of these two levels is almost the same.[1]

This suggestion leads to the following electronic configuration in which actinium becomes the first member of a new series (similar to the position of lanthanum in the rare earth series). This series then has an electronic configuration similar to the rare earth series and should have like properties.

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[1] See Energy-orbital Chart, in Pauling, "Nature of Chemical Bond," Cornell Univ. Press, 1939, p. 26.

NEW CLASSIFICATION (CALLED ACTINIDE SERIES) OF ELECTRON ORBITS

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	6d	7s
89	Ac	filled orbits										2	6	10		2	6	1	2
90	Th											2	6	10	*1*	2	6	1	2
91	Pa											2	6	10	*2*	2	6	1	2
92	U											2	6	10	*3*	2	6	1	2
93	Np											2	6	10	*4*	2	6	1	2
94	Pu											2	6	10	*5*	2	6	1	2
95	Am											2	6	10	*6*	2	6	1	2
96	Cm											2	6	10	*7*	2	6	1	2

These elements can now be compared with the rare earth series which have the following configuration

RARE EARTHS (CALLED LANTHANIDE SERIES)

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	6d	7s
57	La	2	2	6	2	6	10	2	6	10		2	6	1		2			
58	Ce	filled orbits						2	6	10	*1*	2	6	1		2			
59	Pr							2	6	10	*2*	2	6	1		2			
60	Nd							2	6	10	*3*	2	6	1		2			
61	Il							2	6	10	*4*	2	6	1		2			
62	Sm							2	6	10	*5*	2	6	1		2			
63	Eu							2	6	10	*6*	2	6	1		2			
64	Gd							2	6	10	*7*	2	6	1		2			
etc.																			

Such a configuration explains satisfactorily the stable valence state of 4 for thorium which compares with a state of 4 for cerium. It also explains the standard valence state of 3 for the rare earths as well as for the actinide series.

It should be noted that the 7s, 6d and 5f energy levels lie so close together that resonance may predominate and determine which level is lowest. Hence the electron configuration may shift from compound to compound.

The question of the difficulty of separation of the transuranium elements may be raised if they have properties similar to those of the rare earths. It is to be noted here that this series has the additional property of radioactivity which makes it possible to affect certain separations on the basis of the difference in the half-life period. This is noticeable with neptunium^{239} (half-life 2.3 days) and plutonium^{239} (half-life 24,000 years).

Addendum: Since writing this paper information has become available on four more new elements, namely, 43, 61, 85, and 87. The report indicates that earlier claims of the discovery of these elements have been disproved and that they exist only as unstable isotopes made by artificial transmutation processes. This completes the list of 96 elements now known. See "Chemical and Engineering News," 25: 431, 1947.

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Address at Symposium on Nuclear Chemistry at the American Chemical Society Meeting at Atlantic City, April 10, 1946.

THE GENUS EXITIANUS IN NORTH AMERICA INCLUDING MEXICO[1]

(HOMOPTERA: CICADELLIDAE)

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AND
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The genus *Exitianus* was erected by Ball in 1929[2] at which time *Cicadula exitiosa* Uhler = *obscurinervis* Stal was designated as the genotype. At that time Ball included *exitiosa* Uhler, *picatus* Gibson and *miniaturatus* Gibson as synonyms of *obscurinervis*. Ball later (1936) described *kinoanus* as belonging to this genus. An examination of the genitalia of this species places it in *Ollarianus*, the male genitalia being almost exactly the same as those of *bullatus* Ball.

At the time that Osborn placed *exitiosus* Uhler as a synonym of *obscurinervis* Stal he published illustrations of the male and female made from the Stal types by Madam Ekblom.[3] An examination of these illustrations in view of the recent studies of materials raises a question regarding the synonomy of *exitiosus*. As a result, *exitiosus* is re-established as a species in the present treatment.

Several thousand specimens collected in Mexico over the past few years have furnished the basis for a study of the species of this genus using the genitalia as a morphologic index of the diverse color patterns and differences in size. The male genitalia are quite similar in type even in the case of species very different in external appearance. The aedeagus and styles are very similar in all the species examined. The pygofers are similar, but the arrangement of the three large spines is apparently indicative of specific types. The pygofer in a few species is distinctive by being shortened and different posteriorly. The female segments are different in several cases and aid in separating certain species such as *picatus* and *excavatus*. It has not been possible to examine specimens of *digressus* V. D.

In addition to treating the previously described species—*obscurinervis*, *exitiosus*, *digressus* and *picatus*—*nigrens* and *tricolor* are described, two species unique in color and form. Also *excavatus* and *abruptus*, two species closely related to *picatus*, are described; and *brevis* and *angulatus* are described as species related to *exitiosus*. In addition two varietal forms of *exitiosus* are being described.

In distribution the species are distributed in relation to altitudes. *Exitiosus* is apparently a low altitude species in both the United States and Mexico. The species described as *nigrens* has been taken only at Cordoba at an elevation of about 2000 feet. Another species described as new, *tricolor*, has been taken at sea level and up to about 2000 feet elevation. *Picatus* has been taken at elevations ranging from 1000 feet to 7500 feet elevation while *excavatus* occurs over the same range of elevations except that it has not been taken at elevations of more than 5000 feet. A species which is described as *angulatus* is apparently a high altitude species and has not been taken at elevations of less than 4000 feet and occurs up to the fir forests at 10,000 feet or more, in such localities as Rio Frio and Desierto de Los Liones. All the species of the genus occur on herbaceous vegetation and are found in the meadows and undergrowth of the forest areas.

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[1] The authors wish to acknowledge with appreciation the assistance obtained from a Grant-in-Aid from the Sigma Xi Research Fund.

[2] Trans. Amer. Ent. Soc., 55:5, 1929.

[3] Annals Carnegie Museum, Vol. 15, Plate 57, Oct., 1924.

THE GENUS

The genus is characterized by a broad, bluntly produced vertex with the margin broadly rounded to the front. The marginal sutures of the clypeus are continuous with those of the front. The appendix of the elytra extend almost around the apical margin. The female ovipositor is usually long, exceeding the pygofer.

KEY TO SPECIES

1. Almost entirely black in color; pronotum, scutellum and elytra without pale markings.. **nigrens**
Pale in color with dark markings.......... 2
2. Pronotum orange with a transverse black band on posterior half, scutellum orange, unmarked.......... **tricolor**
Pronotum pale without a transverse band, scutellum with dark markings.......... 3
3. Margin of vertex marked with two large round black spots.......... 4
Margin of vertex without black spots.......... **digressus**
4. Vertex with a heavy black unbroken band between the eyes.......... 5
Band on vertex narrow, paler in color or broken into spots or bars.......... 7
5. Female last ventral segment truncate or slightly emarginate with a slight tooth at apex. Male pygofer with the spine about half way between ventral and dorsal margins on apical portion.......... **picatus**
Female last ventral segment deeply angularly notched almost half way to the base. Spine of apical portion of male pygofer near ventral margin.......... 6
6. Male pygofer shallowly notched or excavated at about two-thirds its length on dorsal margin, apical protrusion of pygofer on dorsal margin.......... **excavatus**
Pygofer shorter, sloping at half its length to caudal rounded tip at middle of pygofer. **abruptus**
7. Vertex margin with black spots next the eyes.......... **obscurinervis**
Vertex margin without black spots next the eyes.......... 8
8. Male pygofer concavely excavated on dorsal margin near the apex which is longest on dorsal margin.......... 9
Male pygofer with dorsal margin sloping ventrally from about half its length to form the longest portion at about its middle.......... **brevis**
9. Pygofer spine at about middle of pygofer on apical portion.......... **exitiosus**
Pygofer spine on ventral portion at about one-third the distance from the apex. **angulatus**

(**Exitianus picatus** Gibson)

Athysanus picatus Gibson. Proc. Biol. Soc. Wash. 32:26, 1919.
Athysanus minaturatus (Gib.) Proc. Biol. Soc. Wash. 32:26, 1919.

Resembling *exitiosus* in general appearance but with a broad black transverse band between the eyes. Length 3.5–5 mm.

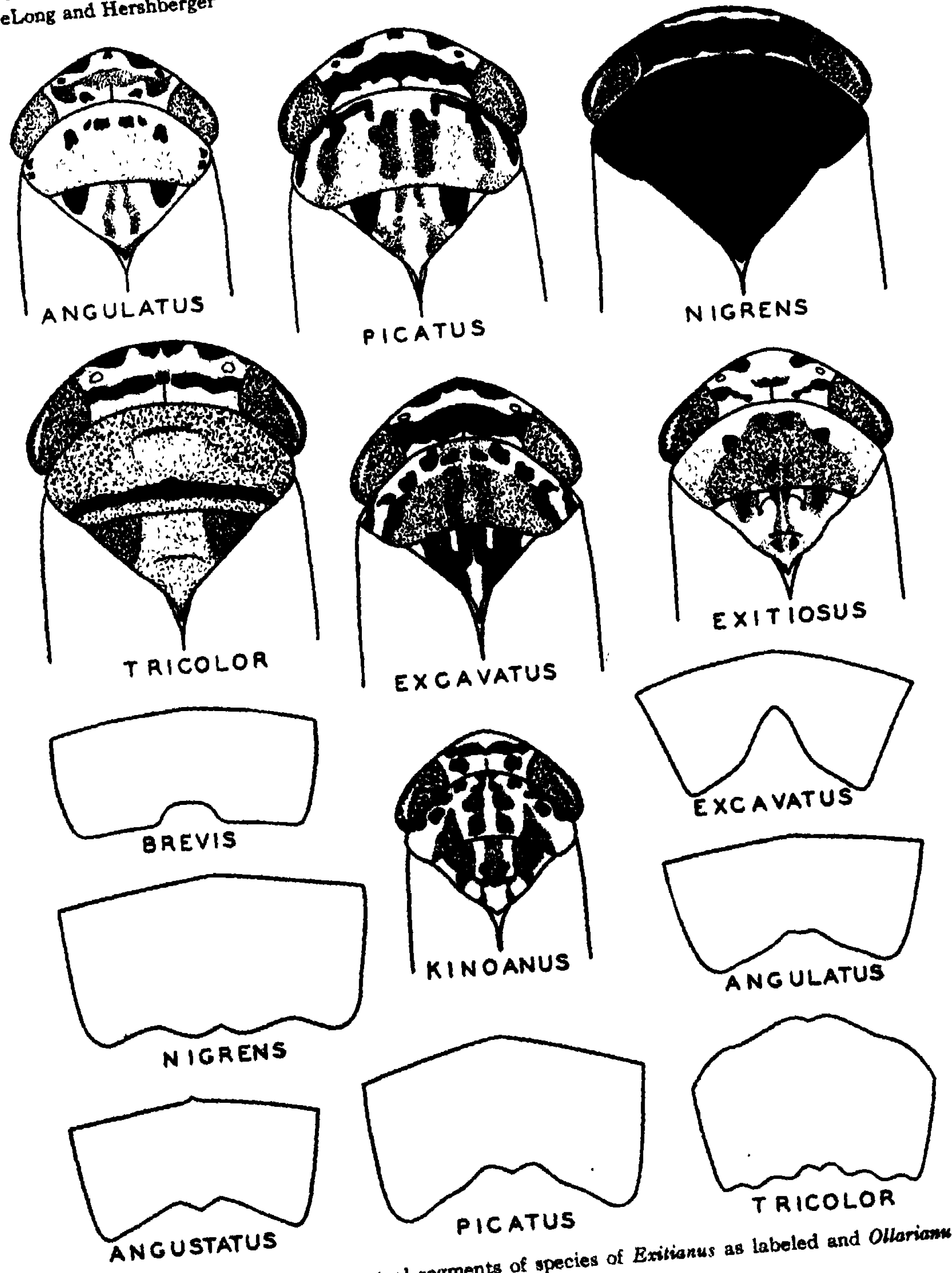
Vertex broad, slightly produced and broadly rounded, twice as broad between eyes at base as median length.

Color: Vertex creamy with a large round black spot just before each ocellus and a pair of minute proximal spots at apex. A transverse black band of median width between the eyes and just back of ocelli. Pronotum pale with a rather large black spot on anterior portion just behind inner margin of each eye. Scutellum pale with a large black triangular spot in each basal angle and a pair of proximal diverging longitudinal lines on anterior median half. Elytra whitish subhyaline with brown veins. Face pale brown with short dark brown arcs at each side. A broad median longitudinal black stripe extends from the margin of vertex to the base of the clypeus. Marginal lines of clypeus and genae dark brown.

Genitalia: Female last ventral segment with posterior margin shallowly, broadly and rather evenly excavated between the produced lateral angles. Male valve broad and triangular; plates long, triangular, tapered to blunt apices. Style rather broad at base, tapered to a narrow outwardly curved apical tip. Aedeagus erect with a basal short broad process extending dor-

PLATE I

The Genus Exitianus
DeLong and Hershberger



Heads and female last ventral segments of species of *Exitianus* as labeled and *Ollarianus kinoanus*.

sally. The apical two-thirds is tapered from a rather broad base to a pointed apex which reaches the dorsal wall of the pygofer and curves anteriorly. The pygofer is elongate with a deep and broad excavation on the dorsal portion just anterior to the apical dorsal lobe. Three prominent spines are on the pygofer two at the apex, the ventral one of which is shorter and broader, and the spine on the apical portion is about half way between the dorsal and ventral margins.

Specimens of this species are at hand from Iguala, Gro., September 11, 1939; Mexico City, November 20, 1938, and September, 1936; Cuernavaca, Mor., September 8, 1939; Balsas, Gro., December 11, 1939; Tierra Blanca, Vera Cruz, July 29, 1932 (M. F. 2655), Vejuca, Gro., September 3, 1930 (M. F. 1790), collected by Dampf, Plummer and DeLong; Jalapa, S. L. P., K-314, Sept. 22, 1945, DeLong, Hershberger, Elliott; Mexcala, Gro., Oct. 2, 1945, Balock, DeLong, Hershberger and Elliott; Tierra Colorado, Gro., October 5, 1945, Balock, DeLong, Hershberger, Elliott; Cuernavaca, Mor., Sept. 25, 1945, Plummer, Shaw, DeLong, Hershberger, Elliott; Zitacuara, Mich , Sept., 1945, Plummer, DeLong, Hershberger, Elliott.

Exitianus excavatus n. sp.

Resembling *picatus* in general appearance but with a more produced vertex, a broader dark band on vertex and with distinct female genitalia. Length 3.5–4.5 mm.

Vertex produced and bluntly angled almost twice as wide between eyes at base as median length.

Color: Pale yellow to white with the black of the upper portion of the face showing as a connecting portion between the two large round black spots on the margin of vertex just before the red ocelli. A broad black band just back of ocelli extends between the eyes and reaches almost to the posterior margin of the vertex. Pronotum with a row of large dark spots on the anterior margin and six longitudinal stripes, the median pair broadest and separated by a narrow pale median line. Scutellum black with a median pale longitudinal spot on the posterior half and four pale longitudinal spots on the anterior margin. There is a small one in each basal angle and one each side about equidistant from each other and from each one in the basal angles. Elytra whitish subhyaline, the veins black. Face black with short pale arcs at either side next antennae, a pale line along clypeus and a pale line along margin of each eye.

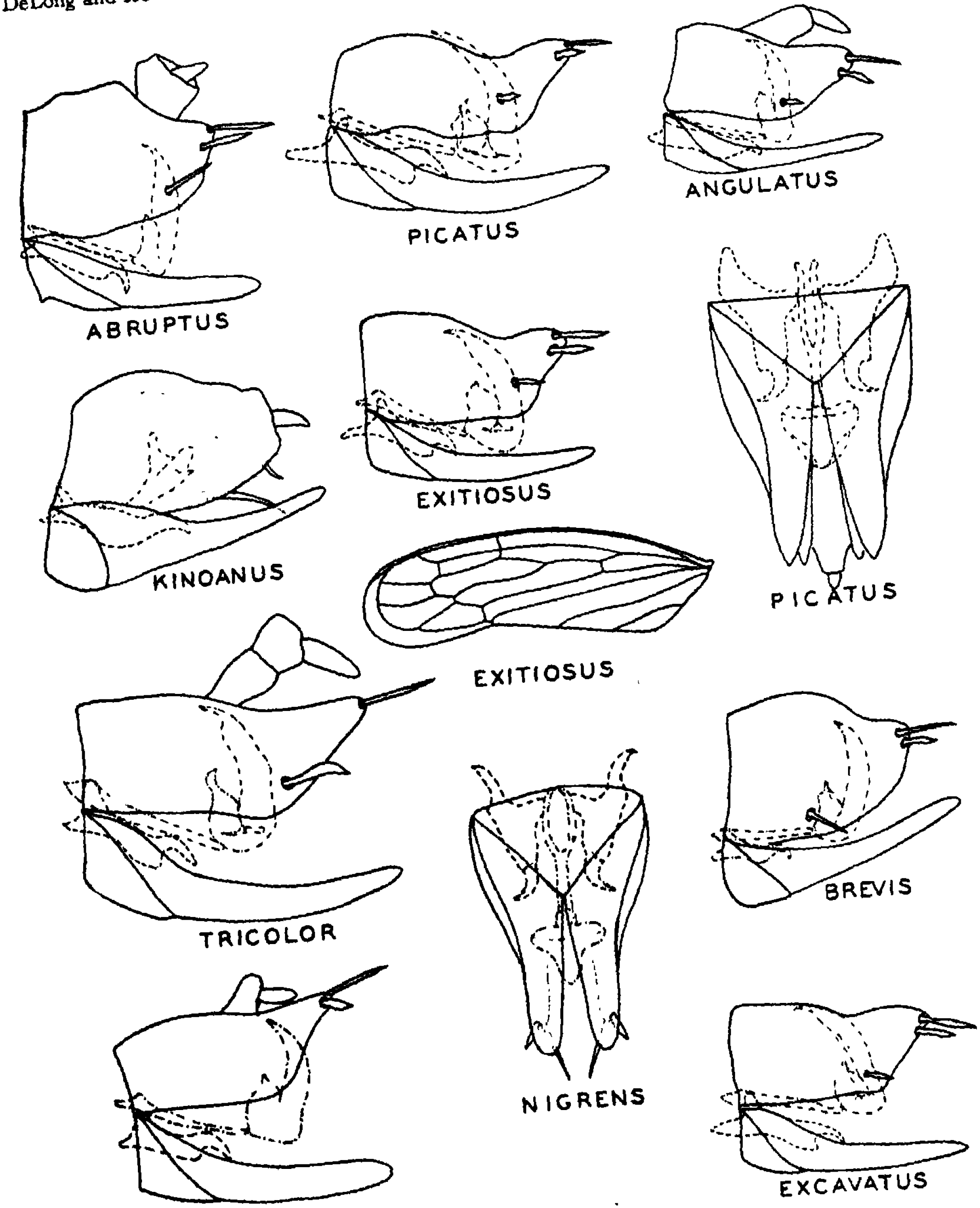
Genitalia: Female last ventral segment with lateral angles prominent, the median third broadly deeply excavated almost half way to the base. The excavation is broad and V-shaped with the apex rounded. Male valve long, triangular; plates long, narrow, blunt at apex, about one-fourth longer than combined basal width. Pygofer elongate, with a broad convex depression on the dorsal portion at about two-thirds the distance from the base with a pair of apical spines on each side, the ventral spine shorter than the dorsal one. A third spine is located about one-fourth the distance from the ventral margin and not far from the posterior margin. The style is rather broad at the base and narrowed to a sharp pointed out-turned apex. The aedeagus is erect with a short broad basal portion and the apical two-thirds is tapered to a sharp pointed apex which is directed anteriorly.

Holotype male collected at Taxco, Gro., September 9, 1939. Allotype female collected at Zamora, Mich., Mexico, on October 2, 1941. Male and female paratypes collected at Jiutepec, Morelos, September 6, 1939; Cuernevaca, Mor., September 8, 1939; Iguala, Gro., September 6, 1939; Acapulco, Gro., September 10, 1939; Chilpancingo, Gro., September 10, 1939; Taxco, Gro., September 9, 1939, collected by Plummer and DeLong. Paratypes from Finca Vergel, Chiapis, May 15, 1935 (M. F. 4177); Tuxtla, Gutierrez, Chiapis, July 2, 1926 (M. F. 1015); Tequila Jalisco. August 24, 1937, collected by Dr. Dampf. A male paratype from Guadalajara, August 27, 1937, was collected by W. E. Stone. Jacala, S. L. P., September 22, 1945, DeLong, Hershberger, Elliott; Necaxa, Pue., October 26, 1945, Stone, DeLong, Hershberger, Elliott.

Exitianus abruptus n. sp.

Resembling *excavatus* in form and general appearance but with the band between eyes narrower, more broken, on posterior margin and male genitalia different. Length, male 4 mm.

PLATE II



ABRUPTUS

PICATUS

ANGULATUS

KINOANUS

EXITIOSUS

EXITIOSUS

PICATUS

TRICOLOR

NIGRENS

BREVIS

NIGRENS

EXCAVATUS

Male genital structures—lateral view as labeled of species of *Exitianus* and ventral view of *Exitianus picatus* and *Exitianus nigrens*. Also the left fore wing of *Exitianus exitiosus* showing the characteristic appendix at apex.

Vertex produced and bluntly angled, almost twice as broad between eyes at base as median length.

Color: Vertex pale with the two large black marginal spots which are joined by the black from the face extending between them. A rather broad black band extends between the eyes. It is irregular on the posterior margin and sends a spur diagonally posteriorly and medially. The pronotum is pale with irregular dark markings extending longitudinally. Scutellum mostly black with white spots in the basal margins and a pair of white spots either side of middle at base and white markings on apex. Elytra pale with dark veins.

Genitalia: Female last ventral segment broadly, deeply excavated about half way to base, the apex of excavation rather broadly rounded. Male valve broad, triangular, the plates exceeding pygofer in length, tapered to blunt apices. Style broad at base narrowed to apices which are sharp pointed and curved outwardly. Aedeagus erect, tapered to a rather sharp pointed apex which is bent anteriorly. The pygofer is a little longer than broad, narrowed both dorsally and ventrally to a blunt apex which bears a pair of spines at the apex and a long ventral spine about one-fourth the distance from the base on apical fourth.

Holotype male and allotype female collected at Jiutepec, Morelos, September 6, 1939, by DeLong and Plummer.

Exitianus obscurinervis (Stal)

Jassus (*Thamnotettix*) *obscurinervis* Stal. Kong. Sven. Vent. Acad. 293, 1858.

This species is apparently closely related to *exitiosus* but according to the illustrations made of the type specimens it is probably distinct. The head is bluntly produced. The margin of the vertex has the two black spots as in *exitiosus* but in addition there is a prominent black spot on the margin next each eye. The band between the eyes is very pale or wanting with prominent spots between the eyes as in *exitiosus*. Length 4–5 mm.

The male and female genitalia are similar in external form to those of *exitiosus*.

The species was originally described from Buenos Ayres, Rio Janeiro.

Exitianus exitiosus (Uhler)

Cicadula exitiosa Uhler. Amer. Ent. 3:72, 1880.

A pale blunt headed species with a broken dark band between the eyes and two round black spots on the margin of the vertex. Length 3.5–4.5 mm.

Vertex blunt, produced, about twice as long between eyes at base as median length.

Color: Vertex pale with a pair of round black spots on margin about half way between vertex and margin of eye. A small spot at vertex and often a smaller spot either side. Ocelli red. A broken transverse band extending between eyes across middle of vertex. Usually with a darker spot at the terminal portions next each eye and a dark spot on either side at base. Pronotum pale to gray with a row of four conspicuous dark spots on anterior portion parallel with the anterior margin. Scutellum pale, a dark triangular spot on each basal angle and a broken line bifid from median basal portion extending to either side of apex. Elytra pale with dark veins and a few dark lines on clavus.

Genitalia: Female last ventral segment with produced lateral angles between which the posterior margin is broadly shallowly excavated with a slightly produced apical tooth at middle. Male valve broadly triangular. Plates long, rather narrow, tapered to blunt apices. The style is rather broad at base narrowed to a slender outwardly curved apical portion which is sharp-pointed at the tip. The aedeagus has a basal portion which is short and broad and which is contiguous with the longer apical portion which extends dorsally and curves anteriorly at the apex. The pygofer is rather long and slender with a prominent rounded indentation on the dorsal portion just anterior to a bluntly produced apical lobe on the dorso-caudal margin. Three prominent spines are on each side of the pygofer; two at the tip of the apical lobe, the ventral one of which is shorter and broader, and a third spine which is shorter than either of the apical spines is located about halfway between the dorsal and ventral margins a little anterior to the apical margin.

This is apparently the proper name which should be applied to the common species which apparently occurs throughout the United States and extends into Mexico. Specimens at hand from many localities throughout the United States show no specific differences. Some of the Mexican specimens are cited as varietal forms of *exitiosus*.

Exitianus exitiosus var. **angustatus** n. var.

Resembling *exitiosus* in general appearance but more slender and elongate with more produced head and different coloration. Length 4.5–5 mm.

Vertex produced and blunt at apex, more than twice as wide between eyes as median length.

Color: Vertex pale yellowish with a large round black spot just before ocellus on each side of middle on margin of vertex, and a minute brownish spot at apex on the margin. A pale brownish band or a broken band extends between the eyes. This is sometimes reduced to spots, one next each eye and an elongate transverse spot on disc. A conspicuous spot either side on base often connected with the spot next the eye. Pronotum yellow to gray with a pair of median spots on anterior margin and a round spot on anterior portion just back of inner margin of the eye. Scutellum with large triangular black spots extending across basal angles. A median longitudinal stripe divides near anterior end and extends across scutellum forming a pair of divergent stripes on apex. Elytra whitish subhyaline, veins black or dark brown. Face pale brown with dark brown arcs usually interrupted at the middle.

Genitalia: Female last ventral segment slightly and broadly excavated on posterior margin between the lateral angles with a very minute median tooth at apex. Male valve triangular; plates long tapered from base to blunt apices. The styles, aedeagus and pygofer are similar to those of *exitiosus*.

Holotype male, allotype female and male and female paratypes collected at Santa Engracia, Mexico, November 8, 1938, by J. S. Caldwell.

Exitianus exitiosus var. **pallidens** n. var.

A pale form resembling *exitiosus* but more robust and with different color markings. Length 3.5–5 mm.

Vertex bluntly angled, a little more than one-half times as long at middle as basal width between the eyes. Female more than twice as broad as long.

Color: Creamy with a pair of round black spots, smaller than those of *exitiosus* on the margin of the vertex, just inside ocelli and a small brownish spot at apex; ocelli reddish. A rather narrow pale brownish band extends between the eyes and there is a tiny black spot either side just before the posterior margin. Pronotum pale, the coloration of scutellum showing through on the disc, a small spot just back of inner margin of each eye on the anterior portion. Scutellum creamy with a black triangular spot in each basal angle. Elytra whitish subhyaline, veins pale brown, the median vein on clavus conspicuously brown. Face yellowish with numerous arcs. Those on upper portion of face almost continuous, the veins on the lower portion broadly interrupted at middle.

Genitalia: Female last ventral segment almost truncate, broadly, shallowly excavated from lateral angles to a short, broad, rounded median tooth at apex. Male valve short, triangular; plates long and narrow, about one-fourth longer than combined width at base, tapered to blunt apices. The styles, aedeagus and pygofer are similar to those of *exitiosus*.

Holotype male, allotype female and male and female paratypes collected at Valles, S. L. P., Mexico, August 28, 1939, and paratypes from Tamazunchale, S. L.,P., August 29, 1939, by D. M. DeLong.

Exitianus angulatus n. sp.

Resembling *exitiosus* in general appearance and coloration but with more produced vertex and female segment notched medially. Length 4 mm.

Vertex rather strongly produced and bluntly angled, not twice as wide between eyes at base as median length.

Color: Creamy, vertex with a pair of large round black spots on margin just before reddish ocelli and a small brownish spot at apex. A curved black transverse band, enlarged next each eye, extends between the eyes. The enlarged portion next each eye is connected with an oblique elongated spot extending medially and basally to pronotum. The discal portion of the pronotum is dark and there is a row of rather large irregular black spots on the anterior portion of the pronotum. Scutellum pale, a large black spot in each basal angle. A pair of proximal round black spots at middle and another pair posterior to these just behind the transverse median line. Elytra white subhyaline, veins brown or black. Face pale brownish with dark brown arcs which extend entirely across the face above but are only on the lateral portions of face below.

Genitalia: Female last ventral segment with produced angles between which the posterior margin is sinuate either side of a broad, shallow median rounded notch greater than the width of the ovipositor. Male valve broad and triangularly produced. Plates long and narrow, tapered to blunt apices. Pygofer long and narrow with the concave excavation on the dorsal margin just before apex There is a pair of spines on the blunt rounded apex. The ventral spine is shorter than the dorsal one. A third spine is on the ventral portion just above margin about one-third the distance from apex. Aedeagus erect with the apex pointed.

Holotype male, allotype female and male and female paratypes collected at Mexico City, D. F., November 20, 1938, by J. S. Caldwell; Toluca Rd., Mexico, November 24, 1938, by J. S. Caldwell; Mexico City, D. F., 18 kms. west, September 1, 1939, and 43 kms. south, September 5, 1939, by DeLong; Mexico City, D. F., September 16, 1936, by W. E. Stone; Jacala, S. L. P., K-314, Sept. 22, 1945, DeLong, Hershberger and Elliott; Tulancingo, Hdg., K-129, October 25, 1945, Stone, DeLong, Hershberger, and Elliott; Rio Frio, D. F., K-65, Oct. 10, 1945, Shaw, DeLong, Hershberger, Elliott; Morelia, Mich., September 30, 1945, Plummer, DeLong, Hershberger, Elliott; Desierto de los Leones, D. F., October 9, 1945, DeLong, Hershberger and Elliott; Rio Tuxpan, Mich., September 29, 1945, Plummer, DeLong, Hershberger, Elliott; Cuernavaca, Mor., September 25, 1945, Plummer, Shaw, DeLong, Hershberger, Elliott; Mexico City, D. F., October 22, 1945, DeLong, Hershberger, Elliott; Zitacuara, Mich., September, 1945, Plummer, DeLong, Hershberger, Elliott.

Exitianus brevis n. sp.

Resembling *angulatus* in general appearance and coloration but with female segment almost truncate with a median shallow excavation and male pygofer short without a dorsal concave emargination. Length 4–5 mm.

Vertex bluntly angled, not quite twice as wide between eyes as median length.

Color: Vertex pale with a pair of large round black spots on anterior margin between which is a smaller spot at apex. The band between the eyes is narrow, broadened on median half, curved anteriorly and sometimes paler in color at middle. A spot either side at base is sometimes connected with the band next the eye. Pronotum with a row of six black spots on anterior margin between the eyes. Scutellum pale with a black triangular spot in each basal angle and a pair of divergent longitudinal stripes at middle which are contiguous at the base and reach the posterior margin on either side of apex. Elytra pale with dark veins.

Genitalia: Female last ventral segment almost truncate on the posterior margin with a rather narrow, shallow, concavely rounded excavation at the middle. Male valve triangular; plates longer than pygofer, elongate, tapered to blunt apices. Style broad at base narrowed to a sharp pointed apex which is curved outwardly. Aedeagus erect, with a short basal portion and a long apical portion which is tapered to a sharp pointed apex; both portions are directed dorsally. The pygofer is short and broad at base, the dorsal margin is concavely narrowed and the ventral margin convexly narrowed at about half its length to form a bluntly pointed apex which bears two prominent spines, the ventral one of which is shorter. A third spine is on the ventral margin at more than half the length of the segment.

Holotype male, paratype male and females collected at Mexico City, D. F., Mexico, November 20, 1938, elevation 7500 feet, by J. S. Caldwell. Allotype female collected at Mexico City, D. F., 43 kilometers south at an elevation of 10,000 feet, September 5, 1939, by Plummer and

DeLong. Paratype female collected on the Toluca Road, 18 kilometers west of Mexico City, September 1, 1939, by D. M. DeLong.

Exitianus digressus (Van Duzee)

Athysanus digressus V. D. Calif. Acad. Sci. 21:32, 1933.

In general form and appearance resembling *exitiosus* but without the black spots on the margin of vertex. Length 4 mm.

Vertex bluntly rounded, more than twice as wide between eyes as median length.

Color: Pale without marginal black spots, the darker forms with a crescent on the vertex above the location of the spots. The band between the eyes is produced anteriorly in triangular form. Elytra pale with pale nervures

Genitalia: Female last ventral segment with posterior margin feebly sinuate. The male plates long, tapered to blunt apices.

This species is known only from Islands in the lower California region, Chatham Island, James Island and North Seymour Island.

This species has not been available for study but is apparently closely related to *obscurinervis*.

Exitianus tricolor n. sp.

Resembling *exitiosus* in general form but with distinct coloration and genitalia. Length 5–6 mm.

Vertex broadly rounded, scarcely produced, appearing almost parallel margined.

Color: Vertex creamy with a large black spot just before each ocellus on the margin, a pair of smaller proximal spots on margin at apex and a minute spot next each eye. A rather narrow transverse black hand, slightly interrupted at middle extending between the anterior margins of the eyes. Pronotum with an anterior marginal band covering the anterior third. The posterior portion pale with a black transverse band about two-thirds the distance from the anterior margin. Scutellum reddish brown unmarked. Elytra milky white with black veins. Face pale with short brown arcs at either side of face. A rather broad median black band extending from margin of vertex to apex of clypeus. A marginal brown line extends from antennal socket along margins of face and clypeus and a marginal brown line between the lorae and genae.

Genitalia: Female last ventral segment with posterior margin slightly slopingly produced to a faint median notch. Male valve triangular, plates long, tapered to blunt apices. Styles rather broad at base tapered to narrow apices which are curved outwardly and pointed at tip. Aedeagus in lateral view rather broad, bent near base and curved dorsally extending to dorsal portion of pygofer. Apical portion tapered to a pointed tip which is bent anteriorly. Pygofer long and narrow, constricted on dorsal margin anterior to the produced bluntly pointed apex. A long spoon-shaped, spine-like structure arising below middle on ventral apical portion and extending posteriorly. A long single spine is at tip of apex.

Holotype male, allotype female and male and female paratype collected at Buena Vista, Gro., October 23, 1941 (K-340) by Good and DeLong. Male paratypes collected at Acapulco, Gro., November 22, 1938, by Caldwell and a male paratype collected by Dr. Dampf at La Libertad near Flores Peten, Guat., swept from grass in a Savanna region November 23, 1935 (M. B. 146).

Exitianus nigrens n. sp.

A black robust species with few pale markings. More robust and shorter than *exitiosus* and with *entirely different coloration. Length 5 to 5.5 mm.*

Vertex broad and broadly rounded, appearing parallel margined only slightly produced at middle.

Color: Black. There is a rather broad white band extending between the ocelli just above the anterior margin and a white marginal band on base of vertex. This gives the appearance of a broad black band between the eyes covering most of the vertex behind the ocelli. The pronotum, scutellum and elytra are shining black unmarked. Face shining black with about four pale spots on lower portion. Beneath black.

Genitalia: The female last ventral segment is almost truncate. The posterior margin is sinuate either side of the median third which is slightly produced and faintly notched at the middle. Male plates slender, elongate; apices distinctly rounded. Valve triangular, extending about to apex of styles. The style is broad at base, gradually narrowed to pointed apex which is bent outwardly. Aedeagus resembling that of *obscurinervis*. There is a short, basal, dorsally produced process which is broad and fits against the dorsally produced apical portion. The latter is rather broad at the base and tapers to a pointed apex which is bent cephalad. The pygofer is concavely narrowed before the apex both ventrally and dorsally to form a narrow protruded apical portion at the tip of which there is a long slender spine just dorsal to a short broad thumb-like spine.

The holotype male and allotype female were collected at Cordoba, Vera Cruz, October 8, 1941, by Good, Plummer, Caldwell and DeLong.

Ollarianus kinoanus (Ball)

Exitianus kinoanus Ball, Bull. of Brooklyn Ent. Soc. 31:72, 1936

In general appearance and coloration, resembling *exitiosus* but without the apical appendix and other characteristics of *Exitianus*. Length 4 mm.

The vertex is similar in length and width to *exitiosus* and is broadly, bluntly produced.

Color: Pale brownish marked with black and dark brown spots and blotches. A pair of black spots on margin are similar to those of species of *Exitianus*. A transverse band between these crosses the vertex before the anterior margin of the eyes. A pair of dark blotches on the basal portion near the eyes. Elytra white, subhyaline; brown nervures.

Genitalia: Female last ventral segment with the median fourth triangularly produced on the posterior margin. Male plates rather broad at base narrowed and produced to form long, attenuate, slightly divergent apices. The internal structures are almost exactly like those of *Ollarianus bullatus*. The aedeagus is short and broadened at apex with an anterior median and slight posterior processes The pygofer bears a long dorsal process which arises before the middle and extends caudally and ventrally and tapers to a pointed apex. The ventral process arises at about the middle and extends caudally and ventrally and is shorter than the dorsal process.

Although Dr. Ball described this species as belonging to *Exitianus*, the similarity of the male genital structures to *strictus* and especially *bullatus* leaves little doubt that it should be placed in that genus. It has been taken only in the southwest United States in Tucson and other proximal localities and at Kino Bay, Sonora, Mexico.

Physics of the Twentieth Century

Pascual Jordan has written a fine survey of the concepts of twentieth century physics from his vantage point at the border between theoretical physics and metaphysics. His picture is clearly delineated, well organized, and skillfully presented. It resembles a photograph in that everything is presented from a single point of view. The author develops certain philosophic implications of modern physics and mentions a few experiments which establish his points. Everything else is omitted. Some who look at twentieth century physics will see radios, radar, cyclotrons and other atom smashers, nuclear energy, and a wealth of physical knowledge which has revolutionized the lives and fears of common men. Not Jordan! He sees (a) the development of relativity theory, (b) the evidence that energy is "atomic" in nature, and (c) the uncertainty principle, which has changed the physicist's attitude toward causality and related problems. These theories are of great importance and certainly rank high among the contributions of the past half century, but they do not stand alone.

In the latter part of his book Jordan devotes considerable attention to such topics as the "liquidation of materialism" and "positivism and religion" in which he seems deeply engrossed. For anyone who is interested in the abstract concepts underlying physics, and their relationships in the realm of ideas, Jordan's book is well worth reading.—*John N. Cooper*.

Physics of the Twentieth Century. Pascaul Jordan. Physophical Library, Inc., 15 East 40th St., New York, N. Y. 1946. $4.00.

AN EFFECT OF SUB-LETHAL DOSES OF CRYOLITE ON MEXICAN BEAN BEETLE LARVAE, EPILACHNA VARIVESTIS

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Cryolite, sodium fluoaluminate, is one of the many insecticides used for the control of Mexican bean beetle larvae, *Epilachna varivestris*, and according to the review by Carter and Busberg (1939) it has been generally satisfactory. Being a stomach poison toxic action follows ingestion of the material by the insect. In laboratory tests described by Wene and Hansberry (1944) it was found that many bean beetle larvae did not eat a lethal quantity of cryolite in the 24-hour period allowed for feeding on treated foliage. These survivors showed a marked retardation in growth and development. A similar observation was recorded by Ellisor and Floyd (1939) who noted that some larvae of *Ascia rapae* having fed on cryolite may refuse to feed for several days and shrink considerably in size.

Cessation of feeding for varying periods after ingestion of sub-lethal doses of cryolite may retard development due to inadequate nutrition, something akin to starvation, or due to physiological effects within the insect. A comparison of the effects from starvation and sub-lethal doses of cryolite on instar development of the Mexican bean beetle was the object of the studies reported in this note.

Micronized natural cryolite containing 90% sodium fluoaluminate was the test material. It was applied as a spray to bean leaves in the manner described by Wene and Hansberry (1944), the deposit being calculated as 0.0313 mg. per square centimeter of leaf surface. While under observation test insects were placed in finger bowl type cages at a temperature of 80° F.

Bean beetle larvae were reared en masse in the greenhouse. Third and fourth instars were selected for testing shortly after ecdysis, divided into the necessary number of lots and given the prescribed treatments as indicated in the table. Following the periods of starvation or exposure to cryolite treated foliage, the larvae were allowed to feed on untreated leaves. The untreated foliage was changed daily in order to insure palatibility. At 24-hour periods mortality and instar growth was recorded. Only those individuals succeeding in developing to the next instar were included in the data.

The data in Table I shows that third instar larvae which have fed continuously on untreated foliage had a mean instar length of 2.6 days. One day of starvation increased the third instar length to 3.4 days whereas the third instar length of the larvae feeding for 24 hours on cryolite treated foliage was 4.8 days. The larvae consumed very little of the cryolite treated leaf indicating that the cryolite may act as a repellant. Larvae after being starved for 24 hours ate a large amount of leaf area. Those larvae which had fed on the cryolite treated leaf did very little feeding in the following 24 hours when placed on untreated bean leaf. This decrease in feeding along with the increase in instar length indicates that sub-lethal doses affects the insects metabolism in some other manner than starvation does. Two days of starvation increased the instar length to 4.3 days. The average third instar length of larvae feeding for 2 days on cryolite before being placed on untreated foliage was 5.8 days.

The effect of sub-lethal doses of cryolite was tried on fourth instar larvae. As shown by the Table, feeding cryolite for one and three day periods lengthened the instar period more than equal periods of starvation did.

Five third instar larvae consumed approximately 80 per cent of the area of a single leaf in a 24-hour period. About the same amount was consumed in the second day of feeding. Five third instar larvae after one day of starvation consumed about 80 per cent of the area of two leaves in a 24-hour period. Five larvae ate less than two per cent of the leaf area of a cryolite treated leaf in a 24-hour period. These five larvae ate about the same amount of untreated foliage in the next 24-hour period. This brings up a point overlooked many times in field control experiments in that the potential injury of the surviving larvae is reduced and that cryolite may be more effective than the mortality records indicate.

TABLE I

THE EFFECTS OF STARVATION AND SUB-LETHAL DOSES OF CRYOLITE ON THE GROWTH OF MEXICAN BEAN BEETLE LARVAE

TREATMENT*	THIRD INSTAR			FOURTH INSTAR		
	Number Larvae	Per Cent Survival	Mean No. Days of Instar	Number Larvae	Per Cent Survival	Mean No. Days of Instar
Fed continuously	55	100.0	2.6	35	97.1	5.3
1 day of starvation	55	100.0	3.4	34	94.1	6.5
1 day of cryolite treated leaves	93	47.3	4.8	55	61.4	8.1
2 days of starvation	47	76.8	4.3	......	......	......
2 days of cryolite treated leaves	93	44.1	5.8	......	......	......
3 days of starvation	......	......	......	34	79.1	9.3
3 days of cryolite treated leaves	......	......	......	65	24.7	10.3

*After treatment larvae were fed on untreated foliage.

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PROVISIONAL PALEOECOLOGICAL ANALYSIS OF THE DEVONIAN ROCKS OF THE COLUMBUS REGION

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INTRODUCTION

To anyone who collects carefully from the Devonian rocks in the Columbus region, it is soon evident that while there are many fossils that occur in all of the zones of the limestones, there is none that extends from them upward into the overlying Olentangy and Ohio shales. Further study shows that many species are found only in certain sets of strata of the Columbus and Delaware formations. There are two reasons for this distribution: time and change. The time that elapsed while the limestones and shales were being deposited was very long, possibly as much as 20,000,000 years. During this time many species died out (extinction), new species developed (filiation), other species came in from elsewhere (migration), and some species carried on without significant change (propagation). But all during this time conditions in the local seas were constantly changing—minor changes during the deposition time of the Columbus formation, distinct changes beginning with the Delaware, and great changes in Olentangy and Ohio time. The environments and sea-climates in which the marine communities (biocoenoses) lived changed. Many species could live only in certain conditions of bottom (sediments), depth, temperature, dissolved oxygen, illumination, salinity, neighbors, etc. When all of these, or any of these, changed, species either died out if they could not become adjusted to the new situation, or migrated elsewhere. The long-ranging forms (tycoen), such as *Leptaena*, *Atrypa*, *Megastrophia*, evidently could make these adjustments and stuck it out until the situation became too difficult even for them. Short-ranging types (eucoen), like *Nucleocrinus*, *Goldringia*, colonial corals, and many other zone fossils, flourished only while their environment remained at an optimum. To distinguish between the effects of time and change in segments of the geologic past is never easy, and here an attempt will only be made to point out some of the significant environments (biotopes) and their organic communities (biocoenoses) as they are revealed by the rock records of the environments (lithotopes) and their fossil contents (thanatocoenoses). The complete reconstruction of an ancient community is of course practically impossible for a lithotope never contains fossils of all the various organisms of the original biocoenose, only the remains of the few forms equipped with shells or skeletons of some sort.

The analytical columnar section (Figure 1) for the Devonian rocks of the Columbus region will serve to focus the relative positions of the lithotopes to be discussed below. The alphabetical zonation is that established by C. R. Stauffer in 1910; the zone fossils are in part his, and in part, suggested here.

DISCUSSION OF LITHOTOPES AND BIOCOENOSES (THANATOCOENOSES)

Normal Limestone Lithotope:

Here are included the relatively pure limestones of the Delhi member (Zones E, F, G, H), throughout which the same general type of fossil assemblage persists with faunule modifications due to the time factor. The biotope during this time was nearly constant,—warm, clear, shallow, well-illuminated, quiet sea-water of normal salinity.[1] The richly-speciated faunules were composed of mostly benthonic types, comprising several interlocked layer-societies or associations of different bottom levels; the burrowing animals, especially pelecypods (*Conocardium* and *Modiomorpha*); forms living directly on the bottom, fixed or crawling, such as brachiopods, small corals and bryozoa, gastropods and trilobites; forms raised off the bottom by stems or ramose growth modes, such as blastoids, crinoids, large horn corals, colonial corals; and the bottom hugging swimmers (nektobenthon), the frilled, breviconic, and orthoconic cephalopods.

In this "normal" environment flourished the large, heavy-shelled gastropods (*Pleuronotus*, *Turbonopsis*, *Palaeotrochus*) and large nautiloides,—forms which are almost completely absent from higher or lower beds. The corals of this biotope are almost exclusively types suited to a soft bottom lacking solid points for fixation: many species of horn corals and such honeycomb corals with pear-shaped colonies as *Favosites hemisphericus*, all of which lay loose on the substratum. This is in strong contrast to the bushy and sprawling types with fewer free horn corals of the coral biostromes of Zone C.

The mottled weakly pelmatozoic limestones of Zone G show pronounced differential weathering due to the presence of thick, finger-like, anastomosing networks of finer, more-easily weathered material. This may be the highly triturated faecal material of crawling or burrowing detritivores analogous to the modern holothurians, but there is no more direct evidence of these lowly members of the "normal" communities.

Facies α. An interesting facies of the normal environment exists in the upper part of the Delhi member (Zone H). Layers of limestone are composed largely of pelmatozoan remains,—*Nucleocrinus*, crinoid and blastoid stem fragments, and occasional large crinoid heads (*Dolatocrinus* and *Megistocrinus*). Other members of the "normal" biocoenose are not lacking, but are reduced in numbers. From time to time during the deposition of Zone H large patches of the bottom must have been covered by "colonies" of crinoids and blastoids swaying on their stems, the dominants of this society. Sediments accumulated so slowly that rapid burial, necessary for preservation of blastoids and crinoids with stems still attached, did not obtain. The action of scavengers in disarticulating stems and other parts made such preservation even more unlikely. The crinoids were all camerates with stout stems and large calices about the size of peaches. A special associate of these crinoids was the large spiny gastropod, *Platyceras dumosum*. This handsome species belongs to a Devonian genus whose species nearly always occur with crinoids, often actually attached to the calice. This constant association is often considered to have been parasitic but may well have been the more mutually beneficial arrangement, symbiosis.

Another example of Facies α, the crinoid-*Platyceras* layer society, is the thin crinoidal lens in the lower part of the Delaware formation at the Miami quarry, on the Olentangy River two miles north of Bartholomew Run. This is a very restricted occurrence and seems to represent a temporary and local re-establishment of Columbus (Delhi) biotopic conditions. The crinoids are small, and likewise all specimens of *Platyceras* and the closely related *Orthonychia* are small. This thanatocoenose, however, is not a recurrence of any of those of the Delhi, and is quite distinct from those of the rest of the Delaware. It is analogous to that of Zone H, and homologous to that of the Prout limestone of northern Ohio,—a nice instance of homologous lithotopes with analogous thanatocoenoses due to the time factor.

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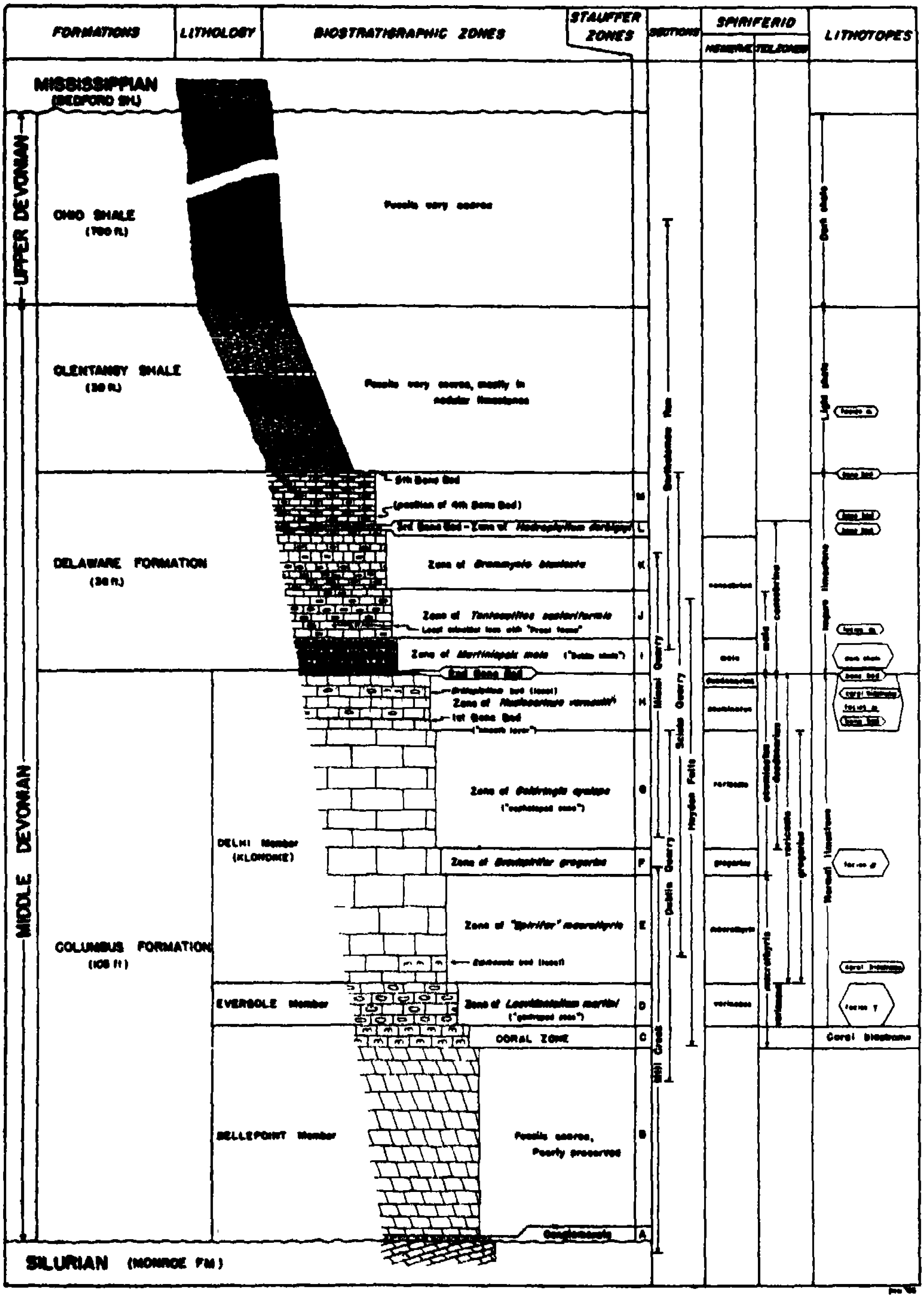
[1] That is, normal salinity for the seas of Devonian times, which must have been appreciably less saline than modern seas.



BIOSTRATIGRAPHIC ANALYSIS OF COLUMBUS DEVONIAN SECTION

FIG. 1. Biostratigraphic analysis of Columbus devonian section.

Facies β. The concentration of *Brevispirifer gregarius* in vast numbers of Zone F represents another facies, one characterized by bottom-lying brachiopods,—a "brachiopod bank." This species is found not only in this zone, but also in the ones just below and above but in much smaller numbers. During the time of Zone F in this region, however, *B. gregarius* reached its local acme and flourished almost to the exclusion of other forms,—a single dominant layer-society. This distribution is a good example of the biostratigraphic concept of the hemera, the acme time of a species, the epibole, the deposits accumulated during the hemera, and the biozone (or more accurately, teilzone), the complete duration, in strata, of a species, thus: the *gregarius*-biozone (teilzone) extends through Zones E, F, and G, the Zone F epibole was deposited during the *gregarius*-hemera. Similarly Zone E is the *macrothysis*-hemera, Zone G the *raricosta*-hemera, while Zone H includes two hemerae, the *acuminatus* in its lower part, the *duodenarius* at its very top, all based upon spiriferids.

The occasional occurrence of conchs of *Goldringia* in the midst of these departed brachiopod hosts of Zone F suggests that this cephalopod may have been a raider that found these banks especially good feeding grounds.

Facies γ. The Eversole chert member, just below the Delhi member, with its lithotope facies of fossiliferous white or gray chert, contains the largest number of species of any unit. Among the 85 species now known, many of those of the "normal" limestone lithotope make their first appearance. Environmental conditions of this lithotope, except for the still practically unknown factors that brought about the periodic accumulation of layers of silica, were the same as for the normal limestones. It would seem that the richness of the faunule is due to the chert rather than a biologic factor. That is, the benthonic biocoenose of the Eversole differed from later ones only insofar as the time factor is involved; the thanatocoenose, however, because of more favorable conditions of preservation, contains many forms unknown or very scarce in other lithotopes.

The most important feature of the Eversole facies thanatocoenose is the large number of species of gastropods,—30, about triple the usual number of the "normal" limestones. Especially abundant are bellerophontids and pleurotomariids. The thinness of the shells of these forms made them particularly liable to destruction before burial and elimination during diagenesis. In the limestones it is rare to find a gastropod with some of its replaced shell. Most are steinkerns. The same applies to the pelecypods, with the exception of the heavy-shelled *Conocardium*.

Chert is not confined to the Eversole member, and is common in Zone H and throughout the Delaware formation. However, in these higher horizons it is almost wholly unfossiliferous except in the bone beds. In the Eversole member the chert was probably a syngenetic silica gel; in the higher members it is of secondary origin, replacing the limestone and appearing as concretionary masses.

Coral Biostrome Lithotope:

True coral reefs do not occur in the limestones of the Columbus region, but in Zone C, the upper few feet of the Bellepoint member, corals are so numerous as to form a large part of the zone and qualify as a biostrome. The lithotope, a brown magnesian limestone with a thanatocoenose of many species of tabulate and rugose corals and stromatoporoids, represents an environment especially favorable for the development of hermatypic corals. Two layer-societies are here commingled, the primary one being that of bottom-hugging types such as horn corals and innumerable large sprawling stromatoporoids, with many of the usual benthic forms of the "normal" limestone biotope. This basal society provided firm sites for the fixation of larger coral colonies which grew away from the bottom to a height of two or three feet; colonial rugosa such as *Diphyphyllum*, *Synaptophyllum* and *Cylindrophyllum*, large massive and ramose tabulates such as *Favosites*, *Emmonsia*, and *Cladopora*. The stimulus for the development of these lotic types was probably more agitated water than prevailed during the deposition time of the higher members.

At a few localities small biostromes of the secondary colonial coral layer society, usually the species *Eridophyllum seriale*, occur a few feet from the top of the Delhi member. One such occurrence is in the old Marble Cliff quarry on the east side of the Scioto River, and similar ones in apparently the same stratigraphic position are found sporadically as far north as Sandusky. Limited biostromes of the massive tabulate, *Emmonsia*, are found at a few places a few feet above the Eversole chert member.

Bone Bed Lithotopes:

The five bone beds of the Columbus and Delaware formations are records of a biotope distinctly different from the preceding. They are thin layers of fragmentary fossils, mostly of small size, and mostly crinoidal or pelmatozoic, mixed with bones, scales, teeth and bits of armor plate of fishes, button corals; the whole forming a coarsely granular, "sandy" limestone. They represent, not the lime-mud depositing conditions of the great bulk of the limestones, but epochs when the sea-bottom was above the base of wave action and fine-grained muds could not accumulate. Erosion (subaqueous) rather than deposition was the order of the day. Under these conditions the bone beds are the concentrated coarse residue of perhaps many feet of lime muds. In places they rest on mud-cracked limestones, indicating occasional exposure.

The bone bed lithotopes record a sandy bottom biotope, a favorable environment for certain benthonic communities. But the composition of these biocoenoses is poorly known because of the slowness of burial and effects of detritivores and scavengers. The fish remains are all of fresh-water forms borne in from Cincinnatia. They are thinly diffused throughout the limestones and concentrated in the bone beds. They are not records of periodic catastrophic annihilation of shoals of marine fishes, as often supposed. Most of the other fossils are the regular eurytropic species of the limestone lithotopes,—species widely adapted to a variety of benthonic situations. In other words, the bone beds have no special faunules, with the possible exception of ostracods, for whom the sandy bottoms were evidently suitable, and the curious stenotopic button-coral, *Hadrophyllum d'orbignyi*, which flourished only on sandy bottoms.

Impure Limestone Lithotope:

This lithotope extends generally through the Delaware formation and especially in Zones J, K, and M. It consists of argillaceous blue to brown limestones, with many scattered dark chert bands, and represents a biotope much less favorable to organisms than the clear waters of the Delhi member. The water was still shallow, but cooler and turbid with fine mud. The thanatocoenoses of less than half as many species in the various zones compared with those of the Delhi member indicate equally reduced biocoenoses. Notable is the practically complete absence of groups common in the normal limestone lithotopes: tabulates, rugose corals, stromatoporoids, blastoids, crinoids, gastropods, cephalopods and trilobites. The faunules consist mostly of brachiopods and pelecypods. The impoverished biocoenoses comprised three main layer-societies: the bottom burrowers or plowers such as *Lingula*, *Grammysia*, and *Nyassa*, the sessile benthonic forms such as most brachiopods and *Glyptodesma*, and occasional shoals of nektonic gastropods (pteropods) such as *Tentaculites*. The stratal distribution of these is different from that in the normal limestones. Instead of being well-mixed assemblages of many species, species commonly occur singly but in large numbers of individuals. Slabs of the Delaware are commonly found covered by hundreds of *Tentaculites scalariformis*, or *Leptaena rhomboidalis*, or Spirifers, *Grammysiae*, *Glyptodesmae*, etc. This fewness of kind with local abundance of individuals is characteristic of waters of abnormal salinities, boreal environments, or very muddy bottoms, as against the abundance of kind with fewer individuals of warm, clear, normally-haline environments. In the present case there is some indication of subhaline conditions during Delaware time, such as the shale facies of Zone I, which has, however, a thanatocoenose distinct from those of the more calacreous lithotopes under consideration. Colder water may account for the great reduction or disappearance of such stenothermic types as corals and crinoids, but not for such eurythermic forms as trilobites, gastropods, and cephalopods. Further and closer study of the Delaware faunules is necessary before a satisfactory resolution of the biotopes can be made, but it is likely that they were subhaline, not so much as in Zone I, and somewhat cooler and decidedly muddier than those of the Delhi. The occurrence in the Delaware of layers such as the bone beds and other crinoidal lenses, containing normal-haline clear-water thanatocoenoses, further emphasizes the distinctness of this lithotope.

Dark Shale Lithotope:

These are exemplified by the Ohio shale and the "Dublin shale" phase of Zone I of the Delaware, and are essentially nearly unfossiliferous bituminous shales. The Ohio shale is black; that of Zone I is dark brown. Both are lithotopes indicative of brackish-water environments; both contain analogous thanatocoenoses of a few species of thin-shelled bracjiopods (*Leiorhynchus*, *Lingula*, and *Orbiculoidea*) with occasional euryhaline wanderers. *Lingula*, a mobile form, lives in muddy bottoms, the others were sessile and probably fixed to seaweed. Conditions were quite impossible for other groups such as corals, crinoids, trilobites, cephalopods, etc. They were less rigorous in the Dublin shale biotope than in that of the Ohio shale, where the blackness of the deposit with much pyrite indicates foul water with very low oxygen content Fossils are fairly common in the Dublin shale and have the characteristic brackish-water facies of few species and many individuals. In the Ohio they are very scarce, and are significant only in the Bellefontaine outlier some 50 miles to the west of the Columbus region, nearer the old shore of Cincinnatia. Here there are several layers near the base of the formation crowded with individuals of *Lingula*, *Orbiculoidea*, *Leiorhynchus* and *Chonetes*, together with the vast numbers of *Styliolina*. The last may represent pelagic dwellers in the better-aerated surface waters. The fish remains of the Ohio, like those of the Middle Devonian limestones, are not those of endemic marine forms, but remains of stray carcasses drifted in from the streams of Cincinnatia. The same origin also applies to the occasional plant remains in the Ohio. Some of the silicified logs of *Callixylon* bear traces of attached or entangled crinoids (*Melocrinus*) that they bore while floating at the surface of the foul-bottomed sea.

The Dublin lithotope is a dark shale facies which passes laterally into the impure limestones of Zone I. These limestones carry the usual thanatocoenoses of the higher zones of the Delaware. Species of the Dublin thanatocoenose likewise pass laterally into the limestones, but those of the limestone do not extend into the shale. The screening off of the biocoenose of the lime mud areas from that of the contemporaneous dark mud areas was probably due to differences of bottom, salinity, and aeration, but mingling in the opposite direction was possible because of the greater environmental tolerance of the species of the brachish-water biotopes.

Light Shale Lithotope:

The Olentangy shale, a slightly calcareous gray-green clayey shale with thin layers of impure limestone, is nearly unfossiliferous. Fossils, except for microscopic forms (ostracods, conodonts, and plant remains), are found almost exclusively in the nodular pyritiferous limestones. The presence of one or two thin layers of black shale in the Olentangy and of occasional layers of green shale in the lower part of the Ohio shale suggest that the Olentangy is a basal phase of the Ohio. Its thanatocoenose consists of a very few forms indicative, not of the brackish-water biotope of the Ohio, but a very impoverished nearly normally saline but uncongenial biotope; one or two small rugose corals, a few bryozoans, several tolerant brachiopods (*Lingula*, *Chonetes*, *Ambocoelia*), an orthoconic nautiloid, and goniatites (*Tornoceras* and *Manticoceras*), and a few others. Neither species nor individuals are abundant. Seemingly this was a depauperate biocoenose of the normal benthonic type eking out a ragged existence against stifling fine muds, most of the time driven out by mud, returning during the brief intervals of reasonably clear water represented by the thin limestones. Occasional crinoid plantations did exist, notably the one at the type locality of the shale near Delaware,—a lens several inches thick of comminuted remains of the large *Melocrinus bainbridgensis*, a species also found in the green layers near the base of the Ohio shale and the probable pseudobenthonic associate of the *Callixylon* logs of that formation.

SUMMARY PALEOECOLOGICAL ANALYSIS BY LITHOTOPES

1. *Normal limestone lithotope:* fine-grained to somewhat crystalline nearly pure limestone, usually thick-bedded, locally weakly pelmatozoic.

    Biotope: normally saline, warm, quiet, clear, shallow water below base level, bottom mainly mud.

    Biocoenose (thanatocoenose): richly speciated benthonic multilayered society of rugose corals, crinoids, byrozoans, brachiopods, large gastropods, large cephalopods, and trilobites.

    Distribution: Delhi member.

    Facies:

    α—crinoidal limestone.
    Biotope: as above, but sandy bottom.
    Biocoenose (thanatocoenose): crinoid-blastoid-*Platyceras* layer society dominant.
    Distribution: Zone H of Delhi member, and Miami Quarry lens of lower Delaware formation. Also the thin crinoid lens in the Olentangy shale at Delaware.

    β—brachiopod limestone (*gregorius*-hemera).
    Biotope: as above.
    Biocoenose (thanatocoenose): sessile brachiopod layer-society dominant.
    Distribution: Zone F of Columbus formation, Delhi member.

    γ—fossiliferous gray-white chert.
    Biotope: as above.
    Biocoenose (thanatocoenose): multi-layered benthonic society, richly speciated, gastropods dominant.
    Distribution: Eversole chert member.

2. *Coral biostrome lithotope:* brown magnesian limestone crowded with corals.

    Biotope: as in normal limestone biotope, but water more agitated.
    Biocoenose (thanatocoenose): dual-layered, lotic coral society dominant.
    Distribution: Zone C; minor occurrences in Zones E and H.

3. *Bone bed lithotope:* crinoidal limestone with heavy concentration of fish remains.
    - *Biotope:* as in normal limestone ,but water agitated, bottom sandy and above wave base.
    - *Biocoenose (thanatocoenose):* dual-layered society, mostly eurytropic forms, dominant.
    - *Distribution:* five bone beds in Delhi member and Delaware formation.
4. *Impure limestone lithotope:* argillaceous blue-brown limestone with chert layers and thin shale bands.
    - *Biotope:* salinity slightly subnormal, cool, muddy water below wave base.
    - *Biocoenose (thanatocoenose):* triple-layered benthonic societies ,restricted faunules, few species, individuals locally abundant.
    - *Distribution:* generally throughout Delaware formation.
5. *Light shale lithotope:* slightly calacreous green-gray shale with thin layers of impure, pyritiferous limestone.
    - *Biotope:* normally saline, warm, but very muddy water below wave base, subnormal oxygen content.
    - *Biocoenose (thanatocoenose):* depauperate, multi-layered society, species and individuals few.
    - *Distribution:* Olentangy shale.
6. *Dark shale lithotope:* brown to black, often pyritiferous, bituminous shale.
    - *Biotope:* brackish water, often foul and poorly aerated except superficially, muddy, below wave base.
    - *Biocoenose (thanatocoenose):* few species of thin-shelled types, with individuals locally numerous, forming two or three layer-societies (surface, on bottom, and in bottom).
    - *Distribution:* Ohio shale and locally in Zone I of Delaware formation.

GALVANOTROPIC RESPONSES OF PARAMECIA TO BALANCED SQUARE WAVES

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Galvanotropism in *Paramecium* has been extensively studied in respect to many variables. Jennings (1906) reviews the earlier investigations and comes to the conclusion that reaction is due to the reversal of effective ciliary stroke on the cathodal surface of the organism. Bancroft (1906) observed that certain salts when added to the environment will cause forward locomotion toward the anode. Stratkewitsch (1907) observed internal pH changes under direct and alternating current. Scheminsky (1926) and Hausman (1929) discussed movement in varying sinusoidal alternating frequencies. Kamada (1928–31) reported on galvanotropism with controlled "current strength," "salt intensity," and time factors. Much quantitative work has been done in respect to direct, interupted direct, and sinusoidal alternating current of varying frequencies.

The quantitative and qualitative studies made possible by electrical stimulation is fully recognized. In order for electrical stimulation to be of value in quantitative studies it is necessary that the current be constant and any interchange instantaneously opposite. This is possible by the use of a balanced square wave as described by the authors in their previous paper (Goldston and Miller, 1947).

PROBLEM

In the behavior laboratory, keeping *Paramecium caudatum* in a normal environment, we applied frequency controlled, balanced square waves, the electrochemical results of which were equal and opposite (Goldston and Miller, 1947). In keeping all other factors constant except frequency of polarity interchange, we observed the reactions of paramecia subjected to frequencies from zero to one hundred thousand cycles per second.

APPARATUS

The method for production of balanced square waves was discussed by the authors in a previous number of this *Journal*. The electronic wave form made available by such mechanisms was found to be applicable to studies in protozoan behavior.

The electrodes were introduced into the ends of an elongated U-shaped culture tube (see Figure 1). A constant plane-to-plane voltage of 45 volts was applied to the culture which approximated 200,000 ohms resistance at all times. This permitted the flow of 0.155 milliamperes. This amperage to which the paramecia were subjected was sufficient to produce definite cathodal galvanotropism without any morphological distortion. Balanced square waves from .25 to 5 cycles per second were produced through the use of the electric dpdt relay. Frequencies from 5 to 100,000 cycles per second were provided by a variable square wave generator.

APPLICATION

A standard culture of *Paramecium caudatum* was secured for the experiment. The organisms were placed within the U-tube and observed through a binocular microscope. The same culture source was used throughout the experiment with frequent changes of samples. Temperature was kept constant at 21° C. Throughout the range of frequencies studied a consistent sample reaction of almost 100% could be noted.

Upon the application of a direct current an almost 100% cathodal movement was noted. The morphology of the individuals was normal. With an instantaneous interchange of polarity, there was an immediate orientation toward the new cathode (see Figure 2).

When the frequency of polarity interchange occured at intervals of two seconds, individual paramecia in following the cathode traversed an ellipse (see Figure 3).

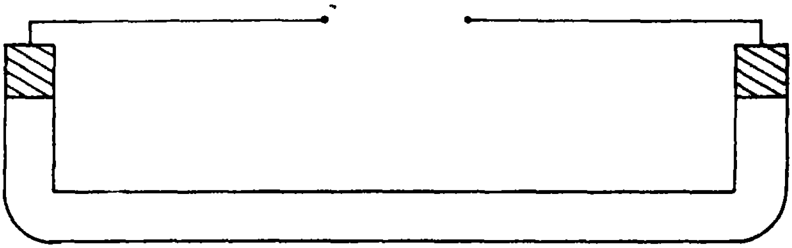

FIG.1

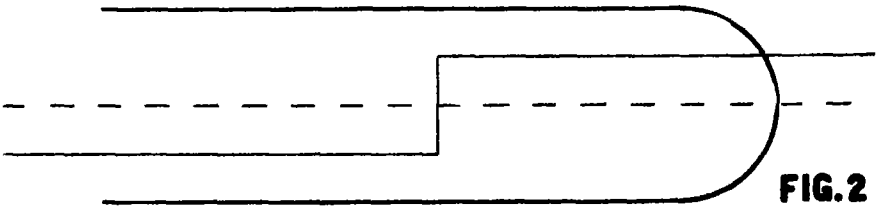

FIG.2

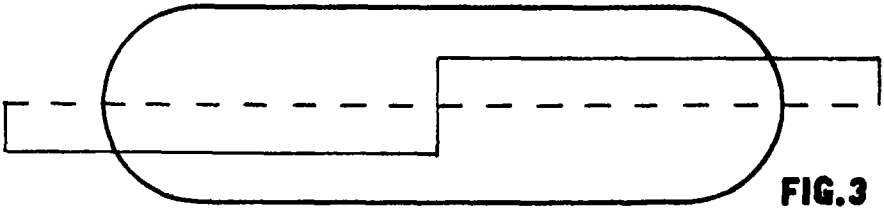

FIG.3

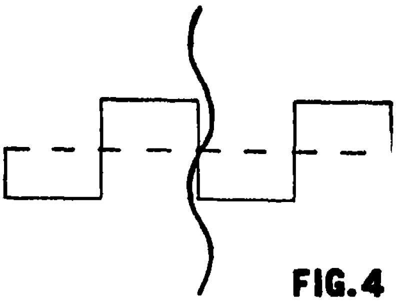

FIG.4

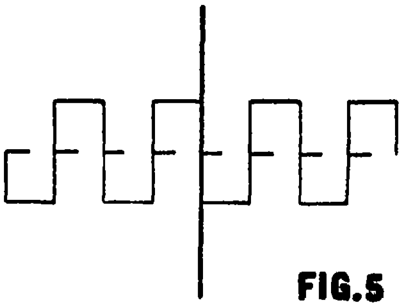

FIG.5

Figure 1. Culture tube used in observation.

Figures 2-5. The paths taken by Paramecia in response to electronic stimulation in relation to the frequency of the balanced square waves. The orientation to a new direction in each instance starts at the point of polarity interchange (not illustrated). See text for details.

Increasing the frequency of polarity interchange to 0.9 seconds resulted in mass movement at right angles to electron flow. The course followed by individuals when subjected to the above frequency was slightly sinusoidal in relation to the tempo of interchange (see Figure 4).

At frequencies of three cycles per second, the general movement continued to be at right angles to current flow, slow forward locomotion was observed with the exception of a few individuals which remained stationary rotating on their long axis.

At a frequency of ten cycles per second a rather smooth path was followed at right angles to the current flow (see Figure 5). Movement was somewhat faster and there was some individual pin-wheeling. Paramecia continued to respond in a like manner throughout the range to five hundred cycles per second. During this change in frequency, individuals were observed to approach normal locomotor speeds. At the upper limits of the range a few individuals were noted to move parallel to current flow for short distances.

From 500 to 1080 cycles per second, the frequency was increased in steps of sixty cycles. The behavior at 1020 was essentially the same as that observed for 500 cycles per second. At 1080 cycles per second perfectly normal behavior was observed. There being no change in behavior between periods when electronic stimulation of this frequency was applied, and when all electronic stimulation was removed. The behavior of the paramecia which appeared to all intent to correspond to the normal behavior at 1080 cycles per second was not altered through further increases in frequency to 100,000 cycles per second.

SUMMARY

Paramecia exhibit definite cathodal galvanotropism when subjected to direct current at low amperage. When stimulation is in the form of balanced square waves, the electro-chemical results of which are equal and opposite, and varying only the direction and duration of electron flow, the organisms were observed to alter their reactions in response to frequency variation.

At the lowest range of frequencies tested, paramecia move parallel to electron flow, reversing direction upon polarity interchange, thereby travelling in an elongated elliptical path, the long axis of which is parallel to electron flow.

Increasing frequency of polarity interchange shortens the long axis of the elliptical path, finally reaching a point where both axes are equal and the path is circular.

Increasing the frequency of polarity interchange beyond this point and up to 1080 cycles per second paramecia traverse a path at right angles to electron flow. At 1080 cycles and beyond there is no discernable difference in behavior between paramecia subjected to the current and paramecia in the normal culture.

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NEW ZYGNEMATACEAE FROM ECUADOR

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The freshwater algae of Ecuador have received very little attention, especially during the past fifty years. Such notices as have appeared are very brief and there have been no extensive lists to convey even a general idea as to the species which exist there, and their distribution. This is partly because the botanists of the country and those who have traveled in Ecuador have had their attention justifiably occupied by the very rich and seemingly inexhaustible terrestrial flora. It is not surprising, therefore, that algal collections, especially from the interior wilds, should yield additions to the records for Ecuador, and new or otherwise interesting species.

While on quinine exploration for the U. S. Government the author had occasion to make a few collections of algae, mostly from alpine regions. One habitat was a series of hanging bogs among old, grass-covered hills of volcanic ash on the flanks of Volcano Cotopaxi. This towering mountain rises in the eastern cordillera about 50 K. southeast from the capital city of Quito, itself located high on the inter-Andean plateau. The hanging bogs and shallow ponds visited on Cotopaxi varied in altitude from 12,500 to 14,000 feet. Most of them were grassy and some were carpeted with moss. One pond in particular, apparently somewhat acid, was very rich in variety of species, especially desmids. Scarcely any Oedogoniaceae were fruiting, and of the many Zygnemataceae only a few were in identifiable condition. Three of these species, described below, were new and seemed worthy of publication as preliminary to a subsequent more extensive report on the algae of Ecuador.

The author is greatly indebted to Dr. E. N. Transeau for his assistance in making identifications and preparing descriptions, and to Dr. Hannah Croasdale for Latin diagnoses. Also acknowledgments are due the Muellhaupt Fellowship, Ohio State University, where studies of the Ecuadorian collections were conducted.

Mougeotia chlamydata, sp. nov., Pl. I, Figs. 9–11.

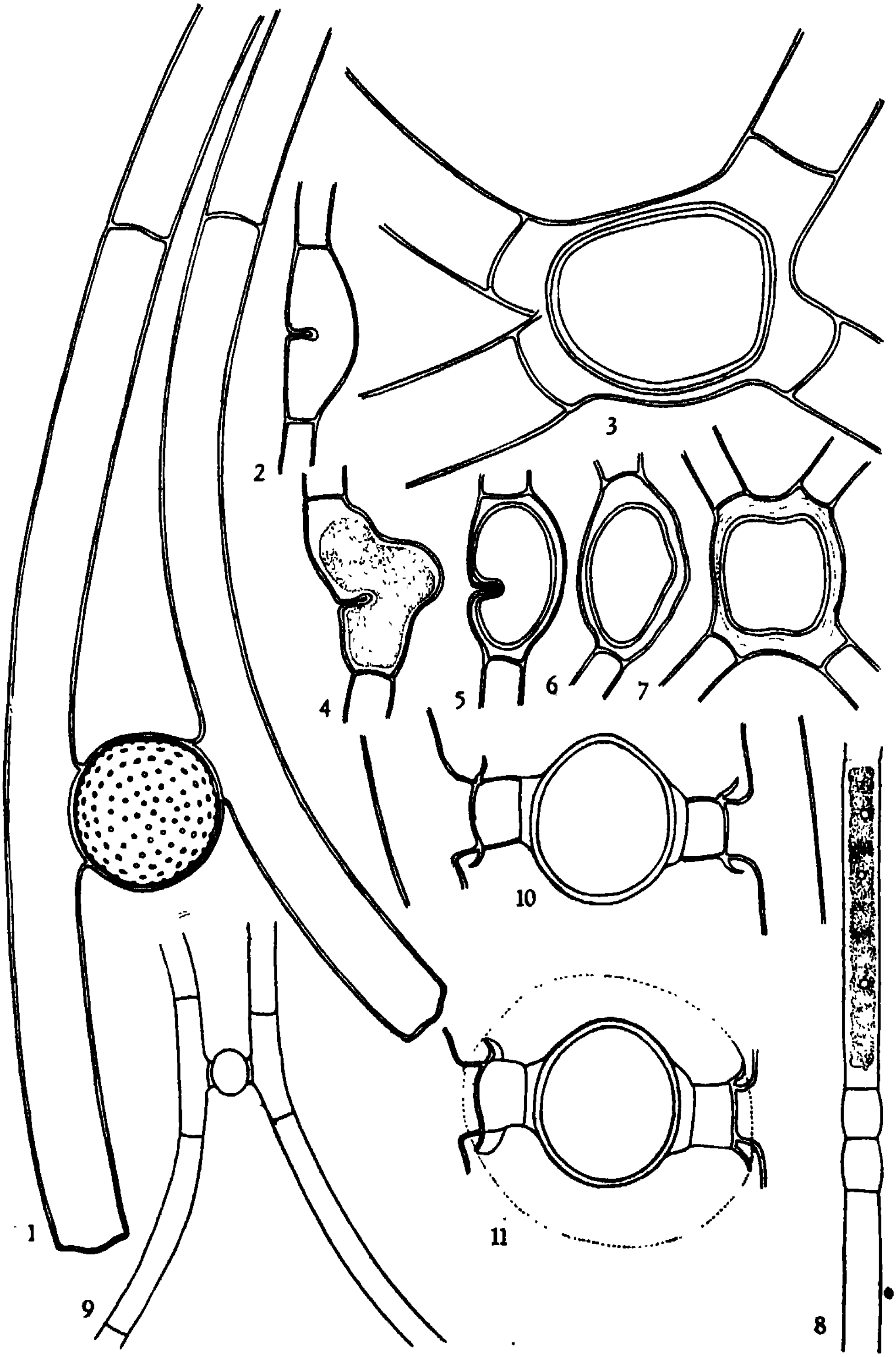
Vegetative cells 12–16 μ x 200–240 μ; chromatophore a narrow band with 4–6 pyrenoids in a row; conjugation scalariform by rather long tubes; zygospores compressed-globose, 26–28 μ x (30) 32–38 μ, outer wall bluish (by refraction), median wall thick, metallic green.

The sporangium wall is characterized by having an inner and outer layer of cellulose, separated by a thick pectic layer. As the spore reaches maturity the outer layer disintegrates equatorially and the pectic layer dissolves leaving a collar with recurved margins at the base of each half of the conjugation tube.

Cellulae vegetative 12–16 μ x 200–240 μ; chromatophorus taeniaformis, 4–6 pyrenoideis seriatis; conjugatio scalariformis tubis sublongis; zygosporae compresso-globosae, 26–28 μ x (30) 32–38 μ, membrana exterior (refractione) subcaerulea, membrana media crassa, metallice viridis.

Membrana sporangii proprie habet stratum cellulosum esterius interiusque per stratum pecticum crassum divisum. Ut spora maturescit stratlum exterius equatorialiter collabitur necnon stratum dissolvitur, collare marginibus recurvatis relinquens ad basim utriusque dimidii tubi conjugentis.

Ecuador: Volcano Cotopaxi; hanging bog at 14,000 ft.



Mougeotia cotopaxensis, sp. nov., Pl. I, Fig. 1.

Vegetative cells 10–15.5 μ x 80–250 μ, chromatophores with 2–4 pyrenoids in a row; conjugation scalariform; zygospores globose or compressed at right angles to the short conjugating tubes, 30–32 μ in diameter, median spore wall steel-blue, scrobiculate with pits about 1 μ in diameter, 4–5 μ apart, outer spore wall thin, smooth.

Cellulae vegetativae 10–15.5 μ x 80–250 μ; chormatophori 2–4 pyrenoideis seriatis praediti; conjugatio scalariformis, zygosporae globosae aut ad tubos breves conjugentes perpendiculariter compressae, 30–32 μ diam., sporae membrana media chalybea, scrobiculata, lacunis circa 1 μ diam., distantibus inter se 4–5 μ; sporae membrana exterior tenuis levisque.

Ecuador: *Volcano Cotopaxi, hanging bog at 14,000 ft.*

Temnogametum transeaui, sp. nov., Pl. I, Figs. 2–8.

Vegetative cells 14–20 μ x 100–400 μ, with a narrow, axial chloroplast, pyrenoids 2–4 in a row; conjugation lateral and scalariform; gametangia 20–22 μ x 20–30 μ at the ends of vegetative cells; zygospores by lateral conjugation obliquely ovoid, 35–42 μ x 80–100 μ; zygospores by scalariform conjugation 40–50 μ x 45–60 μ, median spore wall smooth, pinkish-buff to orange-brown at maturity.

Cellulae vegetativae 14–20 μ x 100–400 μ, chloroplastus axialis, angustus, pyrenoideis 2–4 seriatis, conjugatio lateralis scalariformisque; gametangia 20–22 μ x 20–30 μ in extremis cellulis vegetativis; zygosporae conjugatione laterali oblique ovatae, 35–42 μ x 80–100 μ; zygosporae conjugatione scalariformi 40–50 μ x 45–60 μ; sporae membrana media levis, puniceo-lutea ad flavo-brunneam cum maturuerunt.

Ecuador: Volcano Cotopaxi; hanging bog at 14,000 ft.

ON THE POSSIBILITY OF PRODUCING AN INTERPRETABLE VISUAL IMAGINE ON THE RETINA OF THE DIOPTRICALLY BLIND BY MEANS OF ELECTRIC PHOSPHENES

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When the retina is mechanically stimulated as by the pressure of the finger inserted between the bulb and the rim of the orbit, a sensation of light is produced in the opposite quadrant of the visual field. Such mechanically produced phosphenes have been known and remarked upon for centuries and the phenomenon has been used as evidence for the "projective" nature of vision. Likewise the adequacy of a mechanical or electrical stimulus in the elicitation of a visual sensation has been adduced as proof of the specificity of sensory end-organs.

Since the initiation of a visual sensation by other than an appropriate radiant energy stimulus is a property of the percepient elements of the eye, a study was undertaken to determine the feasibility of adapting the phosphene phenomenon to the production of visual sensations in cases where dioptric medium blindness existed. In these cases the percepient and interpretive elements (retina, optic nerves and tracts and occipital cortex) are intact; vision being hampered by the interposition of a mechanical barrier to the rays of light destined for the retina. Blindness due solely to lenticular, corneal and/or vitreous opacity is never complete, some degree of light perception and projection being maintained. Nevertheless such cases make up the larger percentage of the blind and while theoretically this group is amenable to corrective surgery, the latter is not always practical. One hesitates, for instance in a case of complicated cataract to intervene surgically for fear of losing for the patient that modicum of vision, light perception and projection, which saves the patient from absolute blindness.

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Since the retina may be intact, its utilization for the synthesis of useful visual images in dioptrically blind subjects, is a tantalizing prospect. The recent advances in television engineering might make it possible to correlate such images synchronously with visible transpirations in the external world.

With this object in mind, experiments were begun early in 1942, in anticipation of a large increment in corneal blindness cases that fortunately did not materialize—to lay a groundwork for adaptation of electrical phosphenes to synthetic images. So far this work has had a purely preliminary character. But the information elicited indicates that the construction of a mosaic phosphene "half-tone" by electrical stimulation of the retina, through the intact coats of the eyeball, is possible.

Stimulation of a single rod or cone would produce an image subtending about 60 seconds of visual arc. It was desired to determine how close an approach could be made, by non-visual stimulation through the intact sclera, to this theoretically minimum limit. Normal human subjects who had the lid reflex of one of the eyes abolished by the conjunctival instillation of 2% butyn and whose other eye was covered by a patch, were instructed to rotate the anesthetized eyeball maximally upward and to maintain it in this position while mechanical stimuli were applied as far back as possible in the conjunctival fornix by means of a No. 32 gauge phosphor bronze wire. In this manner it was possible to produce phosphenes close to the foveal area. Such phosphenes were recorded as to position and subjective size, the latter being estimated by subsequent comparison with a set of perimetry targets.

Though only an approximate indication could thus be gained of the possible size of mechanically induced phosphenes, it was evident that all subjects could identify and project those of 2° and over. Separate phosphenes could be produced and spacially projected when the separation of 5° or more was made between the applied wires.

Increasing the pressure upon the applied wire increases the size of the produced phosphene; this seems to be due exclusively to the increase in the size of the scleral distortion cone produced by such pressure. There is no irradiation of image size with mechanical pressure in any form. The situation was different when electrical stimulation was applied through the apposed wire. Using a single negative galvanic stimulus of 5 milliamperes, the resulting phosphene approximated that produced by mechanical pressure. With faradic stimulation, the size of the phosphene increased with the duration of the stimulus; where the latter was for more than a second, there was an irradiation effect resulting in a phosphene that occupied an entire quadrant of the visual field.

Since the phosphene size is apparently a combined function of the area and duration of the stimulus, the latter could be modulated to produce an actual complex mosaic image. In discussing this matter with Dr. William Edson of the Communications Engineering Department of Georgia Technologic Institute, he has stated that the stage of the television art should render it feasible to form such patterns on the retinae of the dioptrically blind by electronic devices. He suggested in this connection a scanning device which would consist of a multi-wired cable, originating in a televisor, the distal end of which would be molded so as to approximate the curvature of the sclera; that the elements of the cable in contact with the sclera would each furnish a regional stimulation in the proper time, sequence and space relationships to coincide with the external picture and to reduplicate the latter as a rough mosaic in the visual field.

A LIST OF THE STONEFLIES, PLECOPTERA, KNOWN TO OCCUR IN SOUTHEASTERN OHIO[1]

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During 1939–1941 collections of stoneflies were made from most of the larger streams and many of the smaller ones in non-glaciated Southeastern Ohio. Athens County was covered very thoroughly and as many trips as possible were made into neighboring counties. The main stream of the Hocking River and some of its smaller branches, Federal Creek, Queer Creek and Salt Creek yielded considerable numbers of specimens. Sunday Creek, Monday Creek and Raccoon Creek were relatively without stonefly populations.

Many specimens in the Ohio University Collection were made available to the author by Dr. Wm. C. Stehr, who also gave many suggestions in the conduct of the survey and generously helped with the problem of transportation. The late Dr. T. H. Frison of the Illinois Natural History Survey kindly checked all determinations. To both of these men the author expresses his appreciation.

Altogether twenty-four species of stoneflies were collected during the survey. A few additional records of the same species and five species not taken during the study were found reported for Ohio in published works on the stoneflies of North America. These have been added to our list and acknowledgment is there made of the source of the data. A few of these are from the glaciated section of Ohio and it is likely that a survey of that portion of the state will yield some additional species for Ohio.

Distribution is given by counties. The names of collectors follow the county records. Since the most of the records are from collections by Wm. C. Stehr and John D. Walker, their records are designated by the letters *S* and *W* respectively. Most of the specimens on which these records are based are either in the collection of Ohio University or the Illinois Natural History Survey. Some of those recorded by Frison and those recorded by Claassen are probably in other collections.

LIST OF PLECOPTERA KNOWN FROM SOUTHEASTERN OHIO

1. *Taeniopteryx fasciata* (Burm.)
   Athens: S
2. *T. maura* (Pictet)
   Athens: S, W, Harold W. Smith
3. *Nemoura divergens* Clsn.
   Athens: S, W
4. *N. venosa* Banks
   Athens: S, W; Tuscararawas: W; Hocking: W; Vinton: W; Washington: S
5. *Leuctra claasseni* Frison
   Athens: S, W; Hocking: W
6. *L. decepta* Clsn.
   Hocking: W
7. *Capnia opis* Newman
   Franklin: L. S. Roach; Hocking: J. N. Knull. These records are given by Frison.

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[1] Paper No. 31 from the Department of Zoology, Ohio University, Athens, Ohio.

8. *Allocapnia forbesi* (Frison)
Athens: S, W

9. *A. pygmaea* (Burm.)
Athens: S, W, Frison; Hocking: Frison

10. *A. vivipara* (Clsn.)
Athens: S, W

11. *A. rickeri* Frison
Athens: Frison; Muskingum: Ross. These are recorded by Frison.

12. *A.* near *granulata* (Clsn.)
Athens: S

13. *Acroneuria abnormis* (Newman)
Athens: S, W; Washington: L. P. Reynolds

14. *A. xanthenes* (Newman)
Athens: S, W

15. *A. perplexa* (Frison)
Athens: S, W, W. P. Porter

16. *A. arida* (Hagen)
Athens: S; Holmes: R. P. Thomas; Ottawa: P. S Shurrager

17. *A. filicis* Frison
Athens: S. This is a paratype series.

18 *A. evoluta* Klap.
Athens: John C. Herron; Ottawa: Clark; Preble: T. Snyder

19. *A. mela* Frison
Athens: John C. Herron; Adams: J. S. Hine. The latter is recorded by Frison

20. *A. lycorias* (Newman)
Recorded from Ohio specimens in the Illinois Natural History Survey Collection by Frison. The species was taken by Stehr in Carter County, Ky., and so is likely to occur in Southeastern Ohio

21 *Perlesta placida* (Hagen)
Athens: S; Holmes: R. P. Thomas; Lucas: S

22. *Hastoperla brevis* (Banks)
Athens: W; Hocking: J. N Knull. The latter is recorded by Frison.

23. *Isoperla bilineata* (Say)
Athens: S; Hocking: W; Tuscarawas: W

24. *I. confusa* Frison
Athens: S, W; Tuscarawas: W

25. *I. duplicata* (Banks)
Athens: S, W; Vinton: W; Hocking: W; Tuscarawas: W
This is by far the commonest species of stonefly in Southeastern Ohio. Nearly as many specimens of it were taken as of all others combined.

26. *I. minuta* (Banks)
Franklin: Recorded from Columbus by Claassen.

27. *Alloperla mediana* Banks
Athens: W

28. *A. imbecilla* (Say)
Hamilton: Recorded from Cincinnati by Claassen.

29. *Neoperla clymene* (Newman)
Athens: S; Ottawa: P. S. Shurrager

SUPPLEMENTARY RECORDS

Mr. Lee Stewart Roach of the Ohio Division of Conservation has kindly furnished the following stonefly records from Black Lick, Franklin County, Ohio. These specimens were also determined to species by the late Dr. T. H. Frison.

This list adds two species to our state records, namely *Capnia vernalis* (Newport) and *Neophasganophora capitata* (Pictet). Of the latter Walker had taken three naiads in Athens County that were questionably so determined by Frison and hence were not included in the foregoing section of this paper.

RECORDS FROM BLACK LICK, FRANKLIN COUNTY, OHIO: L. S. ROACH

Taeniopteryx maura (Pictet) (*nivalis* Fitch)
Capnia vernalis (Newport)
Allocapnia vivipara (Claassen)
Acroneuria arida (Hagen)
    evoluta Klap.
Neophasganophora capitata (Pictet)
Perlesta placida (Hagen)
Isoperla confusa Frison
Neoperla clymene (Newman)

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THE COLORATION OF ANTHER AND CORBICULAR POLLEN

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Recently interest has been centered in bee literature upon pollen, its use by the honey-bee, appropriate substitutes for pollen during a dearth of that food item of the honey-bee, and the importance of the honey-bee in cross-pollination in agriculture.

Literature on pollen is quite diffuse. In the United States excellent work in pollen research has been made by such men as Young (1908) and Wodehouse (1935). Some pollen studies concern the morphology or external structure of the pollen grains, some are directed to their anatomy or internal structure, others consider the chemical constituents of pollen, pollen as a cause of hay-fever, etc.

Most of the pollen studies give little or no notice to the coloration of the pollen grains themselves, and yet it would seem to be one of the important points overlooked. Todd (1941) states that, "The color of pollen is of great economic importance to a beekeeper. Some of the coloring materials are fat-soluble in beeswax. They are the source of the yellow color in beeswax. Some pollens also contain water soluble coloring materials, and they appear to be responsible for the amber color of honey. The fresh nectars so far examined, even from plants that produce dark honey, appear to be colorless." Fischer (1890) one of the great recent investigators of pollen was one of the first to note the importance of pollen color to the student of pollen morphology. Related species of pollen are quite often similar and sometimes the species of a genus can hardly be distinguished from each other except by their color Erdtman (1933) specifies that for a complete analysis of pollen forms in research, notes on their color are also desirable.

Early writers on pollen, such as Grew, Malpighi and others remarked about the coloration of pollen grains and gave some specific identifications. In the 19th century Francis Bauer gave some sketches of pollen with a word or two added about the color. More recently Armbruster and Jacobs (1929) and Oenike (1934–5) give notice to the color of pollen grains but presumably as seen under magnification. Wodehouse (1935) in his monumental work on pollen grains, dismisses the entire subject of coloration with a few introductory words on "the yellow powder" and there is no further reference to pollen colors in his extensive descriptions and classifications. Microscopical journals, the beekeeping journals and a few other writings make an occasional reference to the color of individual species of pollen, but no comprehensive study has been made of this subject.

CORBICULAR POLLEN

It should be noted at once that all color appraisals or emphasis on the importance of pollen color so far (except that of Todd) are for anther pollen, i. e., either the color of the pollen masses on the anthers of flowers or of the individual pollen grains examined. The color of pollen, however, after it has been gathered by the honey-bee and as it is seen by the beekeeper or other observer in the form of pellets being brought into the hive is somewhat different. This type of pollen the author will refer to hereafter as *corbicular* pollen, and this paper refers to the masses of anther pollen and of corbicular pollen and not to individual pollen grains. The word "corbicular" is not to be found in Webster's New International Dictionary (1942) but was used some years ago by Casteel (1912) in describing the process of pollen collecting by the honey-bee. Most naturalists and poets limit the color range of corbicular pollen, referring to it simply as "the golden dust" of the flowers, or the "golden grist" which the bees bring home, or it is spoken of as "the golden foam of pollen." Bee literature itself abounds in generalizations. The color of pollen is said to range from "cream to dark purple" or it may be "all shades, from black to white and many hues of the rainbow." Less frequently are "yellow, orange, red, brown or green" specified. Cheshire (1888) says that the returning bees bring back to the hive "colored material . . some shade of yellow or orange . . . crimson, green and even black . . . " His further references are to the color of the anther pollen of the Rosebay Willow herb and of the Purple Loosestrife not to corbicular pollen. Sempers (1911) lists for the locality of Aikin, Md , 39 plants and 13 colors. Some of these colors seem to be for anther pollen, as "white for Boneset," "greenish white" for the Pear, while "brown" for Wintercress and White Clover seems to refer to corbicular pollen. Later (1912) he specifies corbicular pollen when he states that the honey-bee gathering pollen on the Wild Carrot formed "greenish-white pellets" to take home. Bisson and Vansell (1940) investigating the properties of beeswax list twenty-one plants and fifteen natural colors of the pollen. The reference seems to be to the anther pollen. Vansell (1942) describing pollination factors lists twenty-two plants and gives fifteen colors for the corbicular pollen and adds other load characteristics. Todd and Bretherick (1942) describing the composition of pollen, list thirty plant pollens. Of these six are anther pollens ("hand collected") arranged in five color categories and twenty-four are corbicular pollens ("from the bees") arranged in fourteen color categories An annual feature of the British "Bee Keeping Annual" (1944) is the listing of forty-three English pollen plants and their arrangement in eleven color classes.

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In none of the above writings however was any notice given to the factor of change of coloration. There is a definite need to distinguish between anther pollen color and corbicular pollen color. This paper intends to show that there is an appreciable difference in color between anther and corbicular colors of pollen.

COLOR

Color may have a variety of meanings. While color and hue are used more or less synonymously, in this paper it will be evident that color refers to the general classes of sensations evoked in the nervous system of the eye and hue is a more specific identification of the same. Coloration simply describes the pollen's state of being colored.

There are two classes of colors; the chromatic colors, as reds, yellows, greens and blues, and the achromatic colors, as white and black and the intermediate greys. The latter have no hue and differ from each other only to the extent of their difference or resemblance to white or black. The achromatic colors may be arranged in a scale from black to white with all the intermediate greys between. Median grey at the center would differ equally from black and white and other greys according to their sense differences. This series can be made into a scale by assigning ordinal numerals to each ascending grey from black as zero (0) through median grey, equal to four (4), on to white as eight (8). The same scale may be expressed in terms of percentages. The relationship expressed on this scale is called brilliancy. Thus, black or zero brilliancy; 1 or 12.5%, very low brill.; 2 or 25%, low brill.; 4 or 50% brilliancy; 6 or 75% brill.; 7 or 87.5% brill.; and so on with 8 or 100% brilliancy. The extremes or ideal limits are not realized in practice. The Munsell system uses nine degrees of brilliance, called "value."

Hue is the attribute in respect to which we describe colors as red, yellow, green or blue or any intermediate between two of these. Arranged in a circle they form a color circle. All hues may be described in terms of the four psychologically primary hues red, yellow, green and blue. Red-yellow equally resembles and differs from red and yellow. Between each consecutive pair of primary hues many intermediates may be recognized Thus arbitrary points of division can be established on the hue cycle, whence we have, red, yellowish-red, reddish red-yellow, red-yellow (midway between red and yellow), yellowish red-yellow, reddish-yellow, yellow, greenish yellow, etc. These steps represent equal visual and not physical intervals. The Munsell system uses ten principal hues and has one hundred hue steps in its color cycle

Colors of the same hue and brilliancy may differ from each other in vividness of hue, that is in degree of difference from grey. This attribute is called saturation In terms of these three attributes colors can be arranged in a tridimensional space or color solid, as Fig 1. Two equal cones are placed base to base. The achromatic white and black are represented by either apex, and the grey series of hues are along the vertical axis with median grey in the center. The vertical axis represents brilliancy. Corresponding to each degree of brilliancy is a plane perpendicular to the vertical axis and in this plane lie all the colors of equal brilliance. Hue is represented in each plane cyclically in the order of the color circle. Saturation is represented radially, with the axial points (greys) as reference points of zero saturation. The closer a hue is to the vertical axis, the less its saturation. Hues on the outer edge of the circle have the highest saturation. A scale of saturation similar to that of brilliancy above may be used.

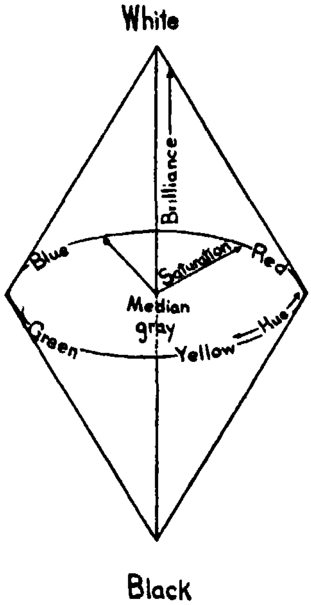

FIG. 1. Color Solid or Tridimensional Color Space Hues are represented cyclically according to the hue cycle, on a plane perpendicular to the axis. The plane's level determines the brilliancy of the various hues. When close to the white apex colors are of great brilliancy and when close to the black point then they are of low brilliancy. Saturation is measured radially on each plane. Maximum saturation is at the rim and zero saturation is at the center.

To express hue, brilliancy and saturation, numerals may be used and they are referred to as color constants or dimensions. This author has used the ordinals (or the percentage values) only to represent saturation and brilliancy. To represent hue the author has used the colorimetric values of the various hues as expressed in wave lengths in millimicrons (mμ). These wave lengths and the scale values of saturation and brilliancy may be called the physical correlates.

COLOR VALUES

The values of the psychologically primary hues, referred to hereafter in the tables are the mathematical mean of the color range as given in The Handbook of Colorimetry (1936), i. e., red, 655 millimicrons (mμ); yellow, 580 mμ; green, 535 mμ; and blue 475 mμ. The values of the intermediates are taken from Judd's (1940) listing, as, yellow-red, 598 mμ; green-yellow, 566 mμ; and blue-green, 495 mμ. For yellowish-red, (English vermillion) 644 mμ; for reddish red-yellow, (Mineral Orange) 614 mμ; and for reddish-yellow (light Chrome yellow) 585 mμ, Rood's (1942) values were taken. The 591 mμ for yellowish yellow-red (Medium gold) is from Nutting (1931), and the Handbook of Colorimetry (1936) supplied the values of yellowish-green (Olive green) 572 mμ; and of yellowish yellow-green (Apple green) 568 mμ. The values of the greenish yellow-green hue, 550 mμ, and of yellowish green 540 mμ are interpolations of this author.

COLOR MATCHING

This entire study it should be noted is not one of color analysis but of color-matching. No spectroradiometer or spectrophotometer was used. The method of color-matching used by the author is the one suggested in A Dictionary of Color (1930). This volume contains reproductions of about 7,000 different colors, but plates numbered 1 to 24 showing the spectral colors from Red to Orange, Orange to Yellow and Yellow to Green (about 2,000 in all) were the most useful. A sheet of neutral grey paper having a reflection factor of about 42.9% was used as a mask to bring a single color into immediate focus. An opening of 9 square millimeters reduced the area of the hue "samples" to a minimum. The color mask was used at all times to check the individual anther or corbicular pollen masses. A linen tester with a focal length of 50 millimeters giving about four magnifications (4×) aided in checking the pollen masses. The illumination used was that of natural daylight on such days as might be termed clear and sunny. Direct sunlight was never used. Most pollens were rechecked within doors under a window having northern exposure, but showed no difference. The color charts of Webster's New International Dictionary (1942) were used to a limited extent and those colors are identified on the list of Table I by the lower case letter "w." Not every hue or color has a name, hence some are referred to only by Plate number, by the column letter and by the row number, as, 9 E 2. At times a closely related color is suggested for the unnamed hues. This is indicated by the symbol ≈ . The author believes he is gifted with normal color vision and the maximum time required for each pollen color check was about twenty minutes.

FIELD METHODS

During the spring and summer seasons of 1944 and 1945 visits were made afield in the New York Metropolitan district and to the Brooklyn and New York Botanical Gardens for anther and corbicular pollen specimens. The characteristic movements, as described by Casteel (1912) and the tell-tale results in the corbiculae of the honey-bee served to distinguish and identify the pollen gatherers from the nectar gathering honey-bee. Bees with fair to large amounts of pollen showing in their corbiculae were seized with a special bee-catcher (Fig. 2) and destroyed with cyanogas in a few seconds. For each specimen a minimum of nine honey-bees were taken. Since Alfonsus (1933) warns that at times drops of propolis may be mistaken for pollen from a distance all specimens were examined under the microscope and identified as pollen. Under more favorable circumstances fifteen to thirty minutes sufficed to obtain the necessary specimens of an individual plant species. Under less favorable circumstances, due to atmospheric conditions affecting dehiscence of the anthers, a much longer time was needed. Shedding of pollen was heavier in the morning and in the late afternoon. Other insects such as bumble-bees, solitary wasps, flies and countless thrips competed with the honey-bee in gathering or consuming the pollen. During a general scarcity of the much-needed pollen an occasional bee was found to work from one kind of flower to that of an entirely different species of flower while grathering pollen. Sladin (1912) in England too observed this occasional mixing of pollen by the honey-bee on a single trip. But that is only by way of exception. Bees show great constancy to a particular kind of flower even though a similar species is near at hand.

Anther pollen was generally checked for color in the field, but never in direct sunlight. Pollen masses large enough to conceal a differently colored pollen sac were removed in entirety, checked against the color chart, and the species and color recorded. Several specimens were used in each instance but no variations were noted. It should be noted, however, that Purple Loosestrife is trimorphus and the different length anthers carry different colored pollen. The Wand Lythrum, *Lythrum virgatum*, of the Brooklyn Botanic Garden, had long anthers with Charteuse colored pollen and short anthers with a Chrome Primrose colored pollen. Corbicular pollen of the bees however was all Yew green. Purple Loosestrife, *L. salicaria*, found near Princeton Junction, N J., however, had long anthers with Bottle green colored pollen and shorter anthers with Chrome Primrose colored pollen. When pollen was scarce or overshadowed by a differently colored pollen sac, an appreciable mass was teased loose and gathered with a probing needle and this mass then checked for color.

The corbicular pollen was checked for color as soon as possible, at least before there was any danger of the pollen becoming "dry." The entire hind leg of the bee was removed, graded for uniformity of color and size of the pollen pellet. With a thumb forceps they were matched for color against the squares of the color charts. The pollen masses were then pried loose from the pollen-basket and rechecked. There was no variation in color as a result. The pollen masses were not, therefore, transparent nor were they influenced by the darker colored tibia of the honey-bee. Some pollen collectors working on a single species of flower showed slightly different colored masses of pollen in the corbiculae, that is, a few would have one color pollen and others a similar or entirely different hue. Parker (1922) also noticed this dissimilarity of color in the pollen masses gathered by the honey-bee from a single species of flower. Thus, he says, bees working on the Box Elder, *Acer negundo*, showed yellow-green corbicular pollen and some showed green pollen. For the Black Maple, *Acer nigra*, some bees had yellow and some had green-yellow pollen. On drying these pollen masses, only one color persisted and under the microscope all the pollen were pure. All "double" colored corbicular pollen reported in Table I was examined by the author and found to be pure.

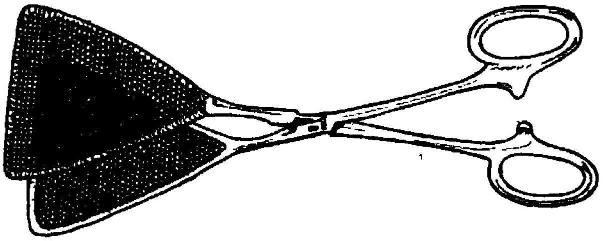

FIG. 2. A bee-catcher. The nine-inch instrument has two triangular spring wire (No. 11 gauge) frames brazed to an arterial clamp. These frames are covered on the outer side with tulle or 13 mesh cotton netting. When closed there is a bee-space (0.25 inch) between the pieces of netting. On smaller flowers the pollen collecting honey-bee and the flower are both grasped together or enclosed between the netted frames, on larger flowers the bee is swept up between the lateral edges of the bee-catcher. The enclosed bee is then held over a cyanogas bottle until destroyed. Between the finger holes is a ratchet locking the device.

The results of the Field Methods and the Color Matching are given in Table I. The flowers listed are entomophilous or insect pollinated. The first column lists the color class and approximate wave length in millimicrons, to which is added the specific hue of the anther pollen. The second column lists the plants examined and their scientific names according to the American Joint Committee on Horticultural Nomenclature (1923). The third column shows the color of the same pollen after it was gathered and packed by the honey-bee in its corbiculae. Two colors listed in this third column indicate that about one-half of the pollen collecting bees showed one colored pollen and about one-half showed the other colored pollen in their corbiculae.

TABLE I

FLORA ARRANGED ACCORDING TO THE COLOR OF THE ANTHER POLLEN AND SHOWING THE CHANGE OF COLOR EFFECTED WHEN THE POLLEN IS COLLECTED BY THE HONEY-BEE IN ITS CORBICULAE.

ANTHER POLLEN COLOR. CLASS AND SP. HUE	SPECIMEN	CORBICULAR POLLEN
YELLOWISH RED. 644 mμ		
Cherry red hue	Red Horsechestnut—*Aesculus carnea*	Raisin hue.
Coral red hue	Common Mignonette—*Reseda odorata*	Zanzibar and Rustic brown.
REDDISH RED YELLOW. 614 mμ		
Burnt orange hue	Wallace Dahurian Lily — *Lilium daurianum wallacei*	Chinook hue.
RED YELLOW. 598 mμ		
Bitter sweet orange hue.	Horsechestnut—*Aesculus hippocastaneum*	Anatolia.
Cadmium orange	Japanese Rose—*Rosa multiflora*	Henna.
	(Hiawatha Rose—*Rosa* sp.)	Henna.
	(Evangeline Rose—*Rosa* sp.)	Chestnut.
	Yellow Hornpoppy—*Glaucium flavum*	Persian orange (w).
Cadmium yellow	Scotch Broom—*Cytisus scoparius*	Punjab.
YELLOWISH RED YELLOW. 591 mμ		
Deep chrome yellow	Winter Hazel—*Corylopsis spicata*	Raw umber (w).
	Yoshino Cherry—*Prunus yedoensis*	Mandarin orange (w).
	Cherry—*Prunus* (*mahaleb*)	Tan and Acorn (w).
	Dandelion—*Taraxacum officinale*	Terra cotta and Raw umber (w).
	Miyama Cherry—*Pr. maximowicii*	Cocoa (w).
	Cypress Euphorbia—*Euph. cyparissas*	Caledonian brown (w).
	White Dutch Clover—*Trifolium repens*	Caledonian brown (w).
	Cathay Japanese Rose—*Rosa multiflora cathayensis*	Terra cotta (w).
	Shirley or Corn Poppy—*Papaver rhoes*	Khaki (w).
	Prairie Rose—*Rosa setigera*	Mandarin orange and Tan (w).
	Deutzia sp.—*D. ningpoensis*	Citrine.
	Wichura Rose—*R. wichuraiana*	Chestnut.
	Common Tansy—*Tanacetum vulgare*	Sunstone.
	Shrubby St. Johnswort—*Hypericum prolificum*	Brass.
	Flowering Plum—*Prunus triloba*, var.	Bronze.

TABLE I—(*Continued*)

Anther Pollen Color. Class and Sp. Hue	Specimen	Corbicular Pollen
Golden yellow	Service berry—*Amelanchier*	Acorn (w).
	Fr. Hugo Rose—*Rosa hugonis*	Raw umber (w).
	Scotch Rose—*R. spinosissima*	Golden yellow and Khaki (w).
	Altai Scotch R.—*R.* sp. *altaica*	Khaki (w).
	Kansas Plum—*Prunus orthosepala*	Kangaroo.
Jonquil yellow	Roxburgh Rose—*R. roxburghi*	Khaki (w).
Yellow ochre	Flowering Cherry—*Prunus serrulata* var. *Gijo*	Chipmunk and Bronze.
	Fl. Cherry—*Pr. ser.* var. *Amanogawa*	Antique bronze.
Reddish Yellow. 585 mμ		
Light chrome yellow	Wreath Goldenrod—*Solidago caesia.*	Whippet.
Lemon chrome yellow	Cornelian Cherry—*Cornus mas*	Yew green (w)
	Winter Honeysuckle—*Lonicera fragrantissima*	Yew green (w).
	Prairie Willow—*Salix humilis*	Olive brown (w).
	Common Box—*Buxus sempervir*	Citrine (w).
	Apple—*Malus sylvestris*	Citrine (w).
	Apple—*Malus sylvestris* (recheck)	Golden yellow.
	Peach—*Amygdalus persica*	Olive brown and Hazel (w).
	Norway Maple—*Acer platanoides*	Acorn and Hazel (w).
	Common Flowering Quince—*Chaenomeles lagenaria*	Lemon chrome (w).
	Bitter Wintercress—*Barbarea vulgaris*	Olive brown (w).
	European Euonymus—*Euonymus europaeus* (Spindlewood)	Mandarin orange (w).
	Morrow Honeysuckle—*Lonicera morrowi*	Khaki (w).
	Lemoine Deutzia—*D. lemoinei*	Citrine (w).
	Sapphireberry Sweetleaf—*Symplocos paniculata*	Raw umber (w).
	Pink Amur Honeysuckle—*Lonicera maacki*	Terra cotta (w).
	Yellow Sweetclover—*Melilotus officinalis*	Auburn and Olive brown (w).
	Roughleaf Dogwood—*Cornus asperifolia*	Serpentine green (w).
	Little Leaf Linden—*Tilia cordata*	Olive brown and Citrine (w).
	White Sweetclover—*Melilotus alba*	Auburn and Hazel (w).
	Canada Goldenrod—*Solidago canadensis*	Whippet.
	Sweet Corn—*Zea mays*	Brass.
	Hupeh Evodia—*Evodia hupehens.*	Deep chrome yellow.
	Frost Grape—*Vitis vulpina*	Ivy green.
Sunflower yellow	Common Portulaca—*Portulaca grandiflora*	11 B 12 (Mandarin orange).
	Bushy Aster—*Aster dumosus*	Bronze yellow.
	Willow—*Salix* sp	Burnished gold.
	Glaucous Willow—*Salix discolor*	Yellow ochre.
	Peony—*Paeonia albiflora* & *P. milkosewitchi*	Tennis and Golden rod yellow.
	Fleabane —*Erigeron flagellaris*	12 J 12 (≈ Tan).

TABLE I—(*Continued*)

ANTHER POLLEN COLOR. CLASS AND SP. HUE	SPECIMEN	CORBICULAR POLLEN
9 L 3 (≈ Sunflower y)	Skydrop Aster—*Aster patens*	Yellow ochre.
	Heath Aster—*A. ericoides*	Burnished gold.
Goldenrod yellow	Floating Heart—*Nymphoides*	Yucatan yellow.
Golden Glow (yellow)	Atlantic Goldenrod—*Solidago arguta*.	11 L 10 (≈ Ponce de Leon yellow).
	St. Bernard Lily—*Anthericum liliago*	Ta Ming.
	White Dutch Clover (recheck).	Antique bronze and 15 J 11 (≈ Whippet).
Chinese yellow	Japanese Pagoda Tree—*Sophora japonica*	Aztec.
9 E 2 (≈ Cream)	Alfalfa—*Medicago sativa*	Khaki.
Pinard yellow	Early Wintercress—*Barbarea praecox*	Olive Green and 14 L 6 (Citrine).
Popcorn yellow	*Narcissus*, var. *Victoria*—Pseudo Narcissus	Rattan.
Chrome lemon yellow	Heartleaf Aster—*Aster cordifolius*	Deep stone.
	Flowering Crab Apple—*Malus bacata*.	13 L 4 (≈ Bistre green).
	Flowering Crab Apple—*Malus atrosanguinea*	Mettalic green.
	Apple—*Malus arnoldiana*	Bistre green.
	Kerria—*Kerria japonica*	Burnished gold.
Colonial yellow	Orpine—*Sedum alboroseum*	13 L 6 (Bistre gr.)
Canary yellow	Welsh Onion—*Allium fistulosum*	Auburn (w).
	Beautyberry—*Calicarpa*.	Acorn and Olive brown (w).
Ivory yellow	Eastern Redbud—*Cercis canadensis*.	Slate grey and Hazel (w).
	Rugosa Rose—*Rosa rugosa*	Slate grey (w).
	Old-fashioned Weigela—*Weigla florida*	Slate grey and Tan bark (w).
	Medlar—*Mespilus germanica*	Olive brown (w).
	Black Locust—*Robina pseudoacacia*	Auburn (w).
	Fragrant Thimbleberry—*Rubus odoratus*	Yew green and Olive brown (w).
	Hupeh Viburnum—*Vib. hupehense*	Slate grey (w).
	Viburnum—*V. scabrellum*	Hazel (w).
	Kashmir Falsespirea—*Sorbaria aitchisoni*	Slate grey (w).
	Common Buglos—*Anchusa officinalis*.	Auburn.
YELLOW. 580 mμ		
Yellow hue	Purple Loosesrtife—*Lythrum salicaria* (0.5, short anthers)	Autumn.
Chrome primrose yellow	*Forsythia*	Citrine (w).
	Japanese Maple—*Acer palmatum*	Khaki (w).
	Siberian Crabapple—*Malus baccata*	Olive brown (w).
	Threelobe Spirea—*Spirea trilobata*	Olive brown (w).

TABLE I—(*Continued*)

ANTHER POLLEN COLOR. CLASS AND SP. HUE	SPECIMEN	CORBICULAR POLLEN
Chrome primrose yellow	Fortune Fontanesia—*Fontanesia fortunei*	Acorn (w).
	Wolf's Lilac—*Syringa wolfi*	Olive brown and Citrine (w).
	Cockspur Hawthorn—*Crataegus crusgali*	Citrine (w).
	Japanese Honeylocust—*Gleditsia japonica*	Citrine (w).
	American Elder—*Sambucus canadensis*	Canary yellow (w).
	Dusty Meadowrue—*Thalictrum glaucum*	Pyrethrum yellow (w).
	Ibota Privet—*Ligustrum ibota*	Citrine (w).
	Narrowleaf Meadowrue—*Thalictrum lucidum*	Olive brown (w)
	Walter Dogwood—*Cornus walteri*.	Citrine (w).
	Largeleaf Dogwood—*C macrophylla*	Olive brown (w).
	Chinese Chestnut—*Castanea mollissima*	Medium chrome green (w).
	Sword Torchlily—*Kniphofia foliosa*	Canary yellow (w).
	Wand Lythrum—*Lyth virgatum* (0.5, short anthers)	Yew green
	White Mignonette—*Reseda alba*	Olive green.
	Purple Loosesrife—*Lythrum salicaria* (0 5, long anthers)	Autumn
Chalcedony yellow	Ural Falsespirea—*Sobaria sorbifolia*	Cub (grey)
	(Tree Falsespirea—*Sorbaria arborea*)	Cub (grey).
Martius yellow	Honeysuckle—*Viburnum sieboldi*.	Olive yellow
	Evergreen Candytuft—*Iberia sempervirens*	14 L 5 (Citrine).
9 K 1 (yellow).	Viburnum—*V. tomentosum*.	Canary yellow.
Chartreuse yellow	Wand Lythrum—*Lyth. virgatum* (0.5, long anthers).	Yew green.
Marguerite yellow.	Thistle—*Cirsium* (*afrum niveum*).	13 G. 3 (Olive sheen)
	Climbing Hempweed—*Mikania scandens*.	13 D 1 (Bronze Clair.)
9 E 1 (yellow)	*Viburnum Opulus*	12 K 4 (Cloudy Amber).
9 F 1 (yellow)	Jetbead—*Rhodotypus scandens*	14 J 2 (Silver Fern).
	Rattlesnake weed—*Hieracum venosum*	Yellow ochre.
9 B 1 (yellow).	Speedwell—*Veronica peduncular*	Italian straw.
9 C 1 (≈ Cream)	Cohosh Bugbane—*Cimicifuga racemosa*	Beech.
	Veronida Teucrium—*Rupestris rosea*	12 H 3 (≈ Hay).
9 D 1 (≈ Cream)	*Rhododendron*	12 H 3.
	Arrowwood Viburnum—*Viburnum. detatum*	13 I 3 (Olive sheen) and 15 J 4 (Olive drab).

TABLE I—(*Continued*)

ANTHER POLLEN COLOR. CLASS AND SP. HUE	SPECIMEN	CORBICULAR POLLEN
GREENISH YELLOW. 572 mμ Chrysolite green	Common Pear—*Pyrus communis.*	Egyptian Green and Marine green (w).
	Pear—*Pyrus*	Medium chrome green (w).
	Kansas Hawthorne—*Crataegus coccinoides*	Citrine (w).
	Alleghany Blackberry—*Rubus allegheniensis*	Slate grey and Median grey (w)
YELLOWISH YELLOW GREEN. 568 mμ Grass green	Roughseed Clammyweed—*Polanisia trachysperma*	Acorn.
GREEN. 535mμ Bottle green	Purple Lythrum—*Lythrum salicaria.*	Gunmetal (Neutral grey and blue red tinge) and Deep chrome green
BLUE RED. 448.5 mμ Egg Plant (hue)	Darwin Tulip	56 A 2+ (Kara Dagh)
Plum (hue)	Oriental Poppy	48 E. 12 (Admiral+)
WHITE	Persian Nepeta—*Nepeta mussini*	Dark grey (w).
	Prickly Comfrey—*Symphytum asperum*	Slate grey (w).
	Menzies *Spirea*—Sp. *menziesi*	Slate grey (w).
	Common Hoarhound—*Marrubium vulgare*	Smoke brown.
	Cutleaf Chastetree—*Vitex negundo*	Dark grey.
	Persian Centaurea—*C. dealbata*	Hemp.
	Mexican Ageratum—*Ageratum houstonianum*	Dark grey.
	Bluestem Joepye weed—*Eupatorium purpureum*	13 K 5 (≈ Bistre green).
	Scabiosa Centaurea—*C. scabiosa.*	12 I 3 (≈ Hay).
	Brownscale Centaurea—*C. jacea*	11 G 3 (≈ Maple).
	Peegee Panicle Hydrangea—*H. paniculata grandiflora.*	Medium grey.
	Orange eye Butterflybush—*Buddleia davidi*	Medium grey.
	Panicle Hydrangea—*H. paniculata.*	Medium grey.
	Morning Glory—*Convolvulus major*	Parchment.
	White Snakeroot—*Eupatorium rugosum*	Cub.
	Caraway—*Carum Carvi*	Olive drab.
	Common Thyme—*Thymus serpyllum vulgaris*	Smoke Brown.

TABLE II

SATURATION AND BRILLIANCY OF THE POLLEN LISTED ON TABLE I

VALUES	IN PERCENT	IN UNITS	SATURATION FREQUENCY		BRILLIANCY FREQUENCY	
			Anther	Corbic	Anther	Corbic
Very high plus.	93.75%	7.5	1	....	1	....
Very high..	87.50%	7	19.5	4.5	100.5	2
High plus .	81.25%	6.5	1	....	....	......
High	75 %	6	43	15.2	19.5	18.7
Medium plus	62.50%	5	..	....	1	1
Medium....	50 %	4	41	47.8	4	55.3
Low plus	37.50%	3	....	1	....	1
Low ..	25 %	2	16.5	54	1	49
Very low	12.50%	1	5	4.5	2	2
			127	127	129	129

The 17 white or achromatic anther pollens are not included in the above listing.

OBSERVATIONS

Of the 146 anther pollens checked, 129 (88.3%) are colored or chromatic. 17 anther pollens were found to be white or achromatic. The samples were taken entirely at random; either as the different flowers were available in one locality or as they blossomed during the course of the two summers in 1944 and 1945. Of the colored anther pollens 57 are reddish yellow, 33 are of a yellow color and 23 are yellowish red yellow. Only 1.5 anther pollens remained unchanged in hue after being gathered by the honey-bee. One was the Common Flowering Quince, having a Lemon Chrome yellow anther pollen and it retained that color in the bees corbiculae. One-half of the bees working on the Scotch Rose, having a Golden yellow anther pollen, had corbicular pollen of that hue, the others showed Khaki colored pollen in the corbiculae. The change was due to a decrease from high saturation and brilliancy to medium saturation and brilliancy.

37.2 other anther pollens did not change in color class, but did change (increase or decrease) in saturation and nearly all of these decreased in brilliancy. All the rest, 107.3 (73%) changed in color class, in most cases also in saturation and brilliancy.

Where two colors are reported in the corbiculae of the honey-bee working on a single species of flower, these colors were often closely related. Thus Zanzibar and Rustic brown, Slate grey and Hazel, Slate grey and Tan bark differed between themselves only in saturation. Golden yellow and Khaki, Auburn and Hazel differed only in saturation and in brilliancy, but not in color class. Other double colors differed in class and sometimes in saturation and in brilliancy.

Among the corbicular pollen colors, 28 are yellow red, 25.8 are yellowish red yellow, 36.2 are reddish yellow, and 15 are yellow.

The anther pollen hues have a Mean wave length of 585.3 mμ and the corbicular pollen hues one of 588.8 mμ. These Means were calculated from 125 variates in each series. The pollen of the Red Horse chestnut, of the Darwin Tulip, of the Oriental Poppy, change to non-spectral hues in the honey-bee's corbiculae, and one-half of the Alleghany Blackberry pollen and one-half of the Purple Lythrum pollen turn grey, while the 17 white anther pollens are achromatic. Hence these 21 variates were disregarded in the calculations. The standard deviation or amount of variability in each series is given in Table III. The coefficients of variation (Table III) show that the corbicular pollen hues are dispersed more round their Mean than are the anther pollen hues.

The difference between the Mean wave lengths is 3.5 mμ. This is significant according to Fisher's (1934) standard, D > 2 x E_D, where D is the difference between the Means, and E_D is the standard error of the difference. That is it is significant if it is greater than twice its standard error. The standard error of the difference (E_D) between the Mean pollen hues is 1.34. This was calculated from Paterson's (1939) formula: $E_D = \sqrt{E_A^2 + E_B^2}$, where E_A equals the standard error $\left(\frac{\sigma}{\sqrt{n}}\right)$ of one quantity and E_B equals the standard error of the other quantity. From the above it is evident that the difference between the Mean pollen hues is significant. Fisher's statistical "t" test gives the same result. The difference is significant if D > t x E_D. According to the Table of "t," in this instance its value is 1.95 times the error of the difference 1.34 equals 2.61. The difference 3.5 in mμ exceeds it and is therefore significant.

TABLE III

COEFFICIENTS OF CORRELATION BETWEEN ANTHER POLLEN AND CORBICULAR POLLEN HUES AND OTHER FACTORS, WITH THEIR PROBABLE ERROR (±), THEIR MEAN VALUE (M), STANDARD DEVIATION (σ), AND COEFFICIENTS OF VARIATION (c. v.).

	Anther Pollen Hues	Anther Pollen Saturation	Anther Pollen Brilliancy	Corbicular Pollen Hues	Corbicular Pollen Saturation	Corbicular Pollen Brilliancy	
Anther pollen hues		+0 4498 ±0 0481 t =6 253	—0 0322 ±0 0586 t =0 359	+0 5795 ±0 0400 t =7 887	+0 1792 ±0 0583 t =2 020	—0 1246 ±0.0589 t =1.410	M = 585 3 mμ σ = 8 49 c. v. = 1 45%
Anther pollen saturation.	+0 4498 ±0 0481 t =6 253		+0 0965 ±0 0588 t =1 095	+0.3170 ±0 0542 t =3.708	+0 4080 ±0 0500 t =4 976	—0 0697 ±0 0591 t =0 788	M = 4 8 (60%) σ = 1 75 c. v. = 36 40%
Anther pollen brilliancy.	—0 0322 ±0 0586 t =0 359	+0 0965 ±0 0588 t =1 095		—0 1045 +0 0596 t =1 166	+0 1118 ±0 0591 t =1 256	+0 3134 ±0 0535 t =3 719	M = 6 7 (83 75%) σ = 0 76 c. v. = 11 38%
Corbicular pollen hues.	+0 5795 ±0 0400 t =7 887	+0 3170 ±0 0542 t =3 708	—0 1045 ±0 0596 t =1 166		+0 3610 ±0 0524 t =4 604	+0 0959 ±0 0597 t =1 068	M =588 8 mμ σ = 12 37 c. v = 2 11%
Corbicular pollen saturation	+0 1792 ±0 0583 t =2 020	+0 4080 ±0 0500 t =4 976	+0 1118 ±0 0591 t =1.256	+0 3610 ±0 0524 t =4 604		+0 5249 +0 0435 t =6.867	M = 3 4 (42 5%) σ = 1 57 c. v. = 46 29%
Corbicular pollen brilliancy.	—0 1246 ±0 0589 t =1 410	—0 0697 ±0 0591 t =0 788	+0 3134 ±0 0535 t =3 719	+0 0959 ±0 0597 t =1 068	+0 5249 ±0 0435 t =6 867		M = 3.5 (43 75%) σ = 1 46 c. v. = 41 19% .

Saturation calculations do not include the white anther pollens as they are without this attribute. 41.2 anther pollens do not decrease in saturation. 12.5 anther pollens increase their hue saturation when collected by the honey-bee. About 57% of the anther pollens decrease in saturation or become "greyer." The lower saturated anther colors show the greater change in saturation.

Mean anther pollen hue saturation is 4.8 (or 60.3%) and for corbicular pollen hues is 3.3 (or 42.4%), the difference being 1.5 (or 18.7%). This difference is greater than twice its standard error (0.20, from Paterson's formula above) and it therefore significant. Applying the "t" test gives the same result. 1.5 > 1.96 (t) x 0.20 equals 0.39.

Only 4.5 anther pollen hues do not decrease in brilliancy. The highly brilliant hues show the greater change in brilliancy.

Mean anther pollen brilliancy, exclusive of the 17 white anther pollen samples, is 6.7 (or 83.7%) and the Mean corbicular pollen hue brilliancy is 3.5 (or 44.5%) a difference of 3.2 (or 40%). This difference greatly exceeds the value of twice its standard error, which latter is 0.14 (from Paterson's formula) and it is therefore significant. The "t" test gives the same result, and Fisher's statistical "F" and "z" tests confirm the above calculations.

Table III gives the values used in the preceding paragraphs, but not the standard error of the difference (E_D) which must be calculated separately from the formula of Paterson given above. The coefficients of variation (c. v.) are however given. These express in percentages the dispersion of the variates around their respective means (M). The unit and decimal values for anther and corbicular pollen hue saturation and brilliancy are interchangeable with percentage values. 1 equals 12.5%, 2 equals 25%, etc. The results will be the same.

Table III also gives the coefficients of correlation (r) between anther and corbicular hues, saturation and brilliancy values. It is understood that the reaction between the given associated variables is not mutual. Anther pollen color constants are in this study the independent factors and corbicular pollen color constants are the dependent factors.

Yule (1919) says that if the coefficient of correlation exceeds four times its probable error it is significant, otherwise its importance is primarily to show positive or negative relationship. The probable errors (following the ± sign) given in Table III were calculated from Peter & Van Voorhis' (1940) formula:

$$PE_r - 0.67449\,\frac{1-r^2}{\sqrt{n}}$$

where "r" of course is the coefficient of correlation and "n" the number of variates.

The more modern and critical "t" might also be used to confirm the significance of the correlation coefficients evaluated. The formula used to calculate the values of "t" are from Paterson (1939);

$$'t' = \frac{r \times \sqrt{n-2}}{\sqrt{1-r^2}}$$

The "t" values are given in Table III following the probable error of the coefficients of variation. From a table of "t" values it will be evident that any such value exceeding 1.959 is significant.

In every instance the anther pollen color constants show their significant influence upon the corresponding corbicular pollen color constants, the latter being the dependent factors. It will also be noticed that saturation values are closely associated with their respective hue values, but brilliancy values are correspondingly independent. Since such is the case, and the decrease in brilliancy from the anther pollen to the corbicular pollen is 40% it seems quite certain that this is the most important factor in effecting the change of color.

CONCLUSIONS

It is not by mere chance that the color changes when anther pollen is gathered by the honey-bee and packed in its corbiculae. The discussion of probable causes for this change is inferential and direct proof is not attempted.

Brilliancy is the lesser correlated factor in regard to hue and yet shows more than twice (40%) as much change as does saturation (18.7%) from the anthers to the corbiculae. Here seems to be the reason for the change of color. The decrease in brilliancy is due to a change in the surface texture of the pollen mass when it is removed from the anthers and formed into pellets in the corbiculae of the honey-bee. Pollen grains are quite freely and loosley attached to the anthers and present *en massé*, a sufficiently rough surface to cause a diffuse reflection of the incident light and consequently affect to a lesser degree the wave lengths which produce the color sensations. When these same pollen grains are gathered by the honey-bee they are compressed by the auricle on the anterior end of the planta of the hind leg of the bee and thus squeezed upward into the pollen basket or corbicula to form the pollen pellet or corbicular pollen mass. In the process of packing the bee also uses the middle legs to pat down the pellets thus formed and render them more compact. This relatively smoother mass surface reduces the diffuse reflection of light and hence alters to a degree in spectral composition the light waves that produce the color sensations. This may be illustrated by comparing the pollen grains to freshly fallen snow. Pollen grains are to a great extent as transparent as ice-crystals and otherwise vie in beauty by their sculpturing with the myriad forms of snowflakes. Freshly fallen snow is a diffuse reflector of light, but when it is trodden down or a crust forms over it this property of reflection is reduced. In like manner when pollen is packed by the bee in the corbiculae it looses much of its brilliancy.

Another reason for the change of color is the addition of moisture to the pollen when it is taken from the anthers of the flowers and packed in the corbiculae. Parker (1922) notes this factor when he says that pollen of two different colors was collected from bees working on the Acer negundo, "but upon drying these (i. e., pollen masses) only one color was persistent." In the pollen packing process very little pollen reaches the corbiculae without becoming thoroughly moist and sometimes the pollen masses are fairly liquid with moisture. This addition of moisture, mostly honey, dulls still further the natural brilliancy of the anther pollen, hence the corbicular pollen masses often appear as if "water-logged." According to Todd and Bretherick's (1942) analysis, corbicular pollen contains a mean 11.6% of water while hand collected, i. e., anther pollen has a mean 9.72% water content. Vivino and Palmer (1944) give a mean 23.89% moisture value for corbicular pollen after partial drying for 24 hours. Todd and Bretherick (1942) also note the presence of water-soluble (and fat-soluble) types of pigments in pollen. Any addition therefore of moisture to anther pollen during the transfer to the corbiculae would naturally tend to dilute the pigment and change the color. Chemical analysis indicates that honey is predominantly used for this moistening function and hence honey solids and water content increase disproportionately in corbicular pollen.

Phillips (1929) showed that even water-white honey absorbs some of the light waves, in the following amounts: blue light, 36%, yellow-green light, 23% and red light 18.5%. Even though the honey-bee uses a comparatively small amount of honey in the pollen packing process this fluid coating on the pollen grains absorbs some of the light waves, twice as much blue as red, and one and one-half as much yellow-green as red. This might account for a slight shift of the mean anther hue of the pollen from the 585.3 mμ toward the reddish end of the color spectrum, or toward the mean corbicular hue of 588.8 mμ.

Since the ether extract in pollen may also contain pigments, its decrease would effect a change of color. Todd and Bretherick (1942) give evidence of this decrease. Hand collected, i. e., anther pollen contains a mean 5.01% ether extract while corbicular pollen contains a mean 4.96% ether extract.

Another factor may be the addition of foreign matter to the corbicular pollen masses in the process of packing by the not always fastidious honey-bee. Corbicular pollen masses under the microscope show bits of fiber, dust, gritty matter resembling tiny particles of coal-like mineral matter, that do not stain and are impervious to the point of a probing needle. Some of these minutiae were estimated at from 200 or more microns in length or breath. Pollen grains range in size from 4.5 microns, the smallest (Forget-me-not) to 200 microns in diameter for the largest (Pumkin). In the corbicular pollen of the White Sweet Clover distinctive lighter colored "flakes" appeared but the effect in this case was to "lighten" the pollen pellets. No count was made of this foreign matter nor was it identified, but its presence generally tends to darken the corbicular pollen masses. While anther pollen is also exposed to contamination from dust in the air, soil, etc., the probability for greater contamination is increased for the honey-bee due to its greater range, its flight activity from flower to flower, and its hairy body serving as a "catch all" for such foreign particles.

SUMMARY

Pollen literature ignores to a great extent the important factor of color. In bee literature seldom is a distinction made between anther and corbicular pollen when speaking of the color of pollen.

Introspectively defined colors may be translated into mathematical terms, by the use of color constants and approximate wave lengths may be assigned to practically all hues. Using a standard color chart, anther and corbicular pollen may be identified by color-matching.

Two seasons' field work show for the 146 specimens examined about ten general classes of color, as yellowish red, red yellow, yellow, greenish yellow, etc., and about one hundred distinct hues as, Cherry red, Coral red, Henna, Rustic brown, etc. Most anther pollens (88.3%) are colored chromatically, the rest are white. Only 1.5 pollens were observed to remain unchanged in color when packed by the honey-bee in its corbiculae. Changes in color may be due to decrease in saturation or a decrease in brilliancy or both, and the changes are significant.

Saturation is closely correlated with its associated hue but brilliancy enjoys greater freedom. Corbicular pollen color constants are the dependent factors in relation to anther pollen color constants, but preserve among themselves the same relationship as do the anther pollen color constants.

Brilliancy's decrease is the important factor in the change of color between anther and corbicular pollen. The decrease is caused by a change of surface texture in the pollen masses, the addition of moisture absorption of light waves by the honey used in packing the pollen, dilution of water-soluble pigments and the addition of foreign matter. Hence corbicular pollen differs in color from its corresponding anther pollen.

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A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF THE HEART—AVES XVI

CHARADRIIFORMES. PART 1[1]

FRED H. GLENNY[2]

As in previous studies on the main arteries in the neck and thorax of birds, the writer herein presents the basic arrangement-pattern of these vessels in six species of Charadriiformes.

The patterns of arteries—derivatives of the embryonic aortic arches and other embryonic vessels of the head and neck region—appear to be significant as evidence in relative degrees of relationships among birds. It may be pointed out that orders, families, and genera with wide differences in the arrangement-patterns may be presumed to be widely divergent in their evolution, whereas those orders or families with uniform or highly similar arrangement-patterns appear to represent groups in which evolution may be regarded as centralized, terminal, or parallel in nature.

MATERIALS

Single specimens of the following species were dissected and diagrams of the arteries in the neck and thorax prepared:

Charadriidae:
  Oxyechus v. vociferus.
Scolopacidae:
  Actitis macularia.......................... #225065 USNM
  Macrorhamphus griseus.
  Philohela minor.
  Pisobia minutilla........................... #223691 USNM
Laridae:
  Larus argentatus.

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Materials for this study were collected by the Division of Birds, United States National Museum, Division of Ornithology, Cleveland Museum of Natural History, Division of Ornithology, Royal Ontario Museum of Zoology, and the writer.

OBSERVATIONS

The basic ordinal arterial arrangement-pattern is characteristic for the species studied.

The innominate artery (2) divides to form the common carotid (8) and subclavian (9) arteries. The latter then gives rise to the coracoid major (10), axillary (11), intercostal (12), and two pectoral (13) arteries in order, while the common carotid gives rise to the thyroid artery (16) and ductus shawi (14) before giving rise to the cervico-vertebral (17) and internal carotid (trunk) (21) arteries. The syringo-tracheal artery (15) arises from the ductus shawi; a short basi-oesophageal

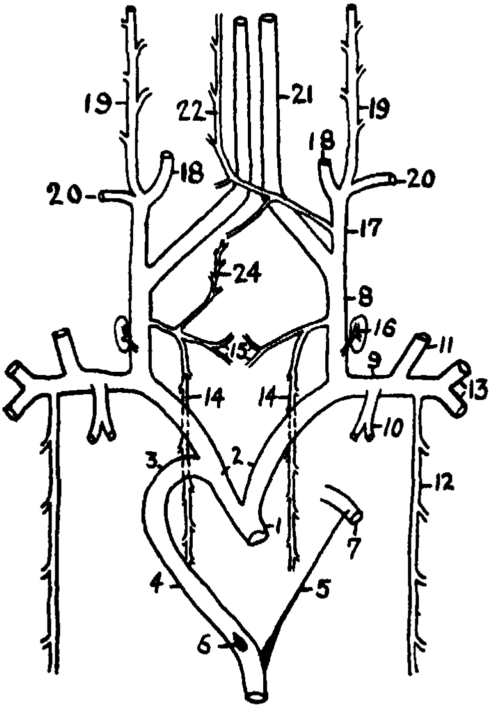

FIG. 1

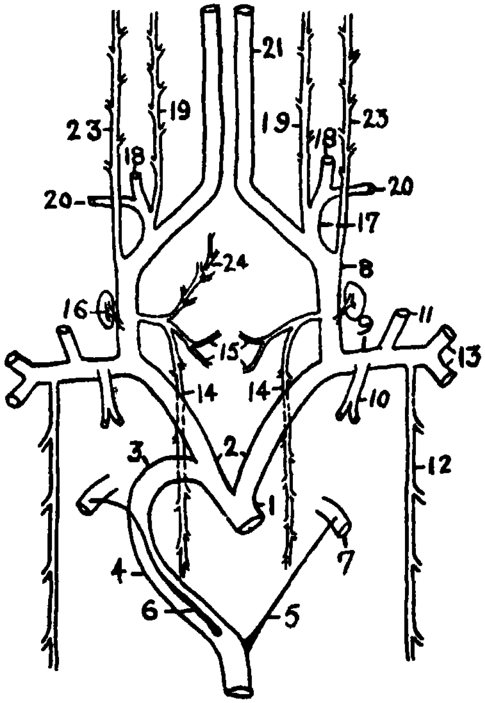

FIG. 2

FIG. 1. Diagram of main arteries of neck and thorax of *Oxyechus v. vociferus*. Ventral view.
FIG. 2. Diagram of main arteries of neck and thorax of *Larus argentatus*. Ventral view.

KEY TO ABBREVIATIONS

1. aortic root.
2. innominate arteries.
3. right systemic (4th aortic) arch.
4. right radix aortae.
5. ligamentum aortae.
6. ligamentum botalli.
7. pulmonary artery.
8. common carotid artery.
9. subclavian artery.
10. coracoid major artery.
11. axillary artery.
12. intercostal artery.
13. pectoral arteries.
14. ductus shawi.
15. syringo-tracheal arteries.
16. thyroid artery.
17. cervico-vertebral artery.
18. vertebral artery.
19. superficial cervical artery.
20. scapular artery.
21. internal carotid (trunk) artery.
22. accessory oesophageal artery.
23. accessory superficial cervical artery.
24. basi-oesophageal artery.

artery (24) arises from the right ductus shawi. The scapular artery (20) arises variously from the cervico-vertebral artery. The ligamentum aortae (5) is present, while the right ligamentum botalli (6) may be present or atrophied in various degrees.

The Charadriiformes are "aves bicarotidinae normales" and both internal carotid (trunk) arteries enter the hypapophysial canal before passing anteriorly to the head.

The right superficial cervical artery (19) normally serves as the ascending-oesophageal artery.

In *Oxyechus vociferus vociferus* (Figure 1) the superficial cervical (19), vertebral (18), and scapular (20) arteries arise from the cervico-vertebral artery (17). An accessory oesophageal artery (22) arises from the left cervico-vertebral artery and passes diagonally across the ventral surface of the neck until it comes to the left side of the oesophagus and then passes anteriorly along its surface. The ligamentum botalli (6) remains as a small "button" at the site of its distal attachment to the right radix aortae (4).

In addition to the basic ordinal pattern, *Larus argentatus* (Figure 2) presents an accessory superficial cervical artery (23) on both left and right sides of the neck. This artery arises from the common carotid just posterior to the origin of the cervico-vertebral artery, and lies more ventral than does the normal superficial cervical (19). In addition to the ligamentum aortae (5), the right ligamentum botalli (6) is present and prominent and maintains both proximal and distal attachments.

Macrorhamphus griseus and *Actitis macularia* are very similar to *Oxyechus v. vociferus* except that (a) there is no noticeable accessory-oesophageal artery (22), (b) the vertebral artery (18) arises nearer the base of the cervico-vertebral artery (17) and (c) the ligamentum botalli (6) is entirely present.

Philohela minor is like *Macrorhamphus griseus* except that the ligamentum botalli appears to be fused with the right radix aortae or completely atrophied.

In *Pisobia minutilla*, the arrangement is the same as that of *Macrorhamphus* except that an accessory superficial cervical, more ventral than the normal superficial cervical, arises from the cervico-vertebral artery on the right side. Both the normal and accessory right superficial cervicals send blood to the oesophagus. The ligamentum botalli is present and complete.

DISCUSSION

From the above observations, it may be seen that although there is a basic ordinal arrangement-pattern of arteries in the neck and thorax of the Charadriiformes, there are also family, as well as individual or specific, variations. This would seem to indicate that the order is fairly well established with respect to evolutionary trends. The various families, however, do not appear to represent terminal forms. This is illustrated in the different families which present patterns somewhat divergent in nature.

The various species, and even families, of this order of birds show relatively less divergence, however, than do many of the species and even families of other orders of birds—Coraciiformes, Anseriformes, and Galliformes (Glenny 1943, 1944, and unpublished papers).

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HOLOCHOANITES ARE ENDOCEROIDS

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INTRODUCTION

The Holochoanites may be defined as those cephalopods in which the septal necks are so elongated that they extend from the septum of which they are a part and a prolongation, apicad to the next septum, or even farther. Hyatt (1884) first regarded the Holochoanoidea as one of two major divisions of the Nautiloidea. Later (1900) he replaced his other division, the Ellipochoanoidea, by four divisions the Orthochaonites, Cyrtochoanites, Schistochoanites and Mixochoanites, and changed the name Holochoanoidea to Holochoanites for uniformity. In the meantime, further study caused him to modify the contents of the holochoanitic division materially. Some genera originally placed in this group, such as *Trocholites*, proved upon further study to possess ellipochoanitic septal necks. The genus *Aturia*, while properly holochoanitic, was removed because it was recognized that it represented a development of elongated septal necks in Tertiary time, which was obviously quite unrelated to that of other holochoanitic cephalopods, few of which survived the close of the Ordovician. Miller and Thompson (1937) showed that the elongation of the septal necks in *Aturia* was a secondary feature and the ellipochoanitic ancestry was indicated by the retention of connecting rings. It was believed that the Holochaonites proper contain cephalopods in which the long necks were primitive, and no connecting rings were developed.

Unfortunately Hyatt does not seem to have committed himself on his ideas concerning the relationship of the Holochoanites with other cephalopods. It is not clear whether this was because of his preoccupation with the phyletic significance of early stages and the controversy that developed about the origin of the Ammonoidea and their relationship to the Nautiloidea, or whether he was as much perplexed by the problem as have been those of us who have come after him in the study of cephalopods. Two lines of evidence seemed at the time to suggest the primitive nature of the Holochoanites. First, the true holochoanitic cephalopods appeared to be concentrated at the bottom of the Paleozoic; only a few discouraged types managed to continue after the close of the Ordovician. Second, a morphological comparison seemed to indicate that a siphuncle wall composed of a single structure, the septal neck, was logically simpler and more primitive than one in which the neck was short and was supplemented by a connecting ring. Indeed, the belief was once suggested that the connecting ring developed as a differentiation of a part of the septal neck. Ruedemann (1905) suggested a possible transition from the holochoanitic to the ellipochoanitic condition by shortening of the septal neck and development of the connecting ring from the endosipholining.

Thin section investigation, however, has presented evidence that holochoanitic structure is not primitive, but that the Ordovician holochoanites developed from ellipochoanitic cephalopods, and retain connecting rings as evidence of their ancestry (Flower, 1941).

The term endoceroid has been variously, and sometimes loosely used but is probably best restricted to cephalopods with relatively large and tubular siphuncles, the interiors of which are occupied by endocones (Flower, 1941). As thus defined it excludes the Ellesmeroceratidae which lack endocones, although from the superficial similarity of the siphuncle wall of *Ellesmeroceras* and true endoceroids, that genus has been considered as an endoceroid by more than one student of the group.

Hyatt (1900) erected the Endoceratida, which has essentially the scope of our Endoceroidea, as a division of the Holochoanites. He regarded it as essentially holochoanitic, a conclusion which it is necessary now to dispute, and suggested that the group might contain cephalopods without organic deposits in the siphuncle. All genera placed in the Endoceratida, however, do contain endocones. Ruedemann (1906) in reporting holochoanitic structure in *Cyclostomiceras* and *Protocycloceras*, believed that they were primitive in this respect, but did not transfer them to the Holochoanites as would appear necessary by definition.

More recent studies have shown that holochoanitic structure is not as widespread as was formerly supposed. Foerste's earlier papers contain many allusions to supposedly widespread holochoanitic siphuncles in pre-Chazyan cephalopods. Several times he asserted the belief that all Canadian and Ozarkian cephalopods were holochoanitic, and on the strength of this premise erected at least one new genus, *Levisoceras*, which he separated as an Ozarkian holochoanitic shell from the ellipochoanitic *Cyrtocerina* of the Ordovician. Further investigations caused him to reject this hypothesis. However, it is a fact that the siphuncle walls of these older cephalopods are often thicker and are more persistently preserved than are those of their younger relatives, and anyone who has seen Tarphyceratidae with a series of camerae completely destroyed except for the siphuncle, can readily understand how Foerste supposed such siphuncles to be composed of the relatively strong septal necks instead of the connecting rings, which in younger cephalopods are often fragile, so fragile indeed that they are often wanting. Indeed, they are practically unknown in some genera, as in *Leurocycloceras* and the Silurian species assigned to *Heracloceras*.

Kobayashi (1935, 1935A, 1936) in a study primarily based upon new morphological evidence supplied by Asiatic cephalopods, found that some shells which are typical endoceroids, as defined above, were not holochoanitic. He proposed a phyletic scheme (Kobayashi, 1935, p. 750) which involved first of all the concept that the endoceroid was not primitive, but was highly specialized. He regarded holochoanitic structure as a specialization, but an early specialization, and interpreted his ellipochoanitic endoceroids as individual departures from a dominantly holochoanitic stock. He regards the Plectronocertaidae as possessing unstable siphuncles which vary from cyrtochoanitic to orthochoanitic. He regards his family Ellesmeroceratidae, however, as varying from holocohanitic in *Ellesmeroceras* to ellipochoanitic in *Clarkeoceras*. The line containing the ellesmeroceroids, the piloceroids and endoceroids, is regarded as dominantly holochoanitic. At three points, the Chilioceratidae, Baltoceratidae and Troedssonellidae, independent transitions from holochoanitic to ellipochoanitic siphuncles are potsulated. A second main line is of somewhat less definite origin. In his diagram, Kobayashi traces it to an unknown ancestor of the Plectronoceratidae but, in his text, notes that it may also have come from the Ellesmeroceratidae. He regards this line as primitively holochoanitic for, branching from it, he places the supposedly holochoanitic Protocycloceratidae and Wolungoceratidae, prior to the point at which he indicates a transition from holochoanitic to ellipochoanitic structure. Beyond this point the line splits producing the orthochoanitic "Orthoceratidae" on one hand and the cyrtochoanitic "Actinoceratidae" on the other.

Of the Protocycloceratidae Kobayashi says: "On the other hand I am inclined to recognize that *Protocycloceras* or *Orygoceras* is a Clycloderatidae or an Orthoceratidae with a holochoanitic siphuncle in which the evolution in reference to the septal character is retarded."

Later investigations support Kobayashi's main thesis of the specialized nature of the Holochoanites but show that they are even more restricted than Kobayashi believed at that time.

Schindewolf (1942) has presented a general concept of nautiloid development which is unfortunately characterized by rather vague definitions of the groups concerned. This has previously been discussed by the writer (Flower, 1946, p. 72). Recently much new information on the older cephalopods has been presented, (Ulrich, Foerste, Miller and Furnish, 1942; Ulrich, Foerste and Miller, 1943; Ulrich, Foerste, Miller and Unklesbay, 1944) but the chert which replaced the substance forming the bulk of the material was not suitable for close morphological study, and the classification is rather generalized, the advances in knowledge of the structure are not great, and little attention is given to the important problems of phylogeny. (See Flower, 1946, p. 73–74).

Investigations on the part of the writer showed that much new information awaited discovery in the siphuncle walls of these older cephalopods. The more important of these results were published (Flower, 1941, 1941a), but much information was omitted as seemingly irrelevant. Thin section study showed that many of the supposedly holochoanitic cephalopods possessed instead ellipochoanitic siphuncles. This is true of the supposedly holochoanitic *Protocycloceras*, *Baltoceras*, *Ellesmeroceras* and *Proterocameroceras*. The evidence of the sections then at hand indicated that many, perhaps most pre-Chazyan cephalopods which were supposedly holochoanitic had instead short septal necks supplemented by connecting rings which were thick enough that they resembled septal necks to a very deceptive extent in opaque sections. Thin sections of well preserved material would show the difference at once. Further, it was found that the connecting rings were often not homogeneous, but developed either a pattern of different layers, or a pattern in which dense and apparently amorphous material termed the eyelet, tended to concentrate in the tip of the ring. The beginning of holochoanitic structure was not definitely placed, but study of Ordovician endoceroids indicated that (1) no longiconic endoceroids prior to the Chazyan possessed good evidence of holochoanitic structure, (2) the holochoanitic septal necks of Chazyan and younger endoceroids were supplemented by a connecting ring which usually agreed with that found in many Canadian ellipochoanitic cephalopods in possessing an eyelet. From these facts it was concluded that the holochoanitic endoceroids developed from ellipochoanitic types which reached their acme in the Canadian, and that the retention of the connecting ring was clear evidence of their ellipochoanitic ancestry. Further investigation indicated strongly that the ellipochoanitic ancestors were properly endoceroids, and that neither the older endoceroids nor their ancestors, the ellesmeroceroids achieved necks long enough to be considered properly holochoanitic. Additional evidence has led to the present statement of these conclusions in the more forceful terms embodied in the title of the present work, and has made possible the presentation of more evidence and the tracing of the phylogeny in more detail than the earlier evidence warranted. The earlier conclusions of the writer (Flower, 1941) were necessarily presented in somewhat general terms. A later brief statement of the phylogeny was included in the introductory portion of the study of the Cincinnatian cephalopods (Flower, 1946, p. 74–90), but the intention of this exposition was to present the evolutionary background of the Upper Ordovician cephalopod faunas, and most of the new evidence bearing upon the problem was passed over or stated only briefly.

PHYLOGENY

The oldest cephalopods comprise the endogastric cyrtocones of the Plectronoceratidae which grade without any precise boundary into the orthoconic cephalopods of the Ellesmeroceratidae. While many genera and species are now known, due to the work of Kobayashi in Asia, and to Ulrich, Foerste and Miller (1942), Ulrich, Foerste, Miller and Unklesbay (1944) in America, details of internal structure are known from only a very few of the specimens. Most of the American material consists of chert internal molds and replacements which are not suitable for a proper morphological study. Some, but plainly not all, of the members of this group possess diaphragms, but it is to be feared that some of the structures termed pseudodiaphragms are not natural but are either adventitious structures or the appearance presented by the rather thick connecting rings in sections which approach close enough to the wall of the siphuncle to intersect it tangentially. These cephalopods have septal necks which are ellipochoanitic or often aneuchoanitic, that is, possessing septa which are scarcely bent apicad at the point where they meet the connecting rings. Study of a considerable suite of specimens has led the writer to reject the holochoanitic siphuncle wall and the presence of diaphragms which Kobayashi (1935a, p. 22, Fig. II), represents for the Ellesmeroceratidae.

The next step in development is that represented by the Proterocameroceratidae (Flower, 1946, p. 80). The siphuncle wall may be as primitive as that of the Ellesmeroceratidae, but within the siphuncle are developed endocones, making these cephalopods true endoceroids. Much variation has been noted in the length of the septal necks in this group; Necks vary from those which are aneuchoanitic to those which approach but do not quite attain the holochoanitic pattern. Likewise, there is here variation between the banded type of connecting ring and that showing the eyelet, with important transitional stages showing the close relationship of these seemingly opposed structural types. There is likewise variation in the form of the endosiphuncle, which may be simple, as appears to be the rule among the Middle Canadian types, or may become quite complex as in the Upper Canadian *Proterocameroceras* or the sole Chazyan member of the stock, *Meniscoceras*.

The next stage in advancement is marked by two contemporaneous modifications, first an elongation of the septal necks until a holochoanitic condition is reached, and second, a tendency for both the shell and the siphuncle to expand very rapidly, although this may be followed in the mature shell by a living chamber which is more or less contracted, so that a typical breviconic shell is eventually formed. This change has reached its acme in the true Piloceratidae. It is believed that some of the Asiatic piloceroid shells may supply a transition from the Proterocameroceratidae to the Piloceratidae in respect to both of these important features. Certainly some of these shells, as *Coreanoceras* and *Manchuroceras*, are only moderately breviconic. Further, it is just among these forms which are transitional in regard to the shell form, in which the rate of expansion of the conch is mainly concerned, that one finds the ellipochoanitic siphuncles. However, Kobayashi has described structures in the endosiphuncles of these cephalopods which indicate that they have undergone very marked specializations of their own. Admittedly, a number of these cephlaopods require further study before their precise position in the phyletic scheme can be definitely established.

At the close of the Canadian the Piloceratidae disappear and the Proterocameroceratidae are represented only by one genus, *Meniscoceras* which penetrates as high as the Middle Chazyan. Their place is taken by slender endoceroids which are regarded as descendants of the Piloceratidae, from which they inherit a tendency for the siphuncle to expand markedly in the early growth stages so that it may occupy the entire apex of the shell, and holochoanitic septal necks which still retain connecting rings. The combination of a slender shell and holochoanitic septal necks has been used as the criterion for the family Endoceratidae. The writer previously believed that some members of this family lost the connecting ring which was retained in the more generalized endoceroids. Further examination of thin sections has, however, indicated that the loss of the connecting ring in those specimens which lack it is more probably the result of solution under unfavorable conditions of preservation. The Piloceratidae-Endoceratidae series is essentially a tachygenetic sequence. Reduce the pattern of a piloceroid phragmocone in size, add to the end a shell in which the siphuncle and conch are both slender, and the resultant type is essentially a *Nanno*, such as persists from the Chazyan to the Richmond. Reduction of the recapitulatory swollen siphuncle of a *Nanno* results first in the inflated, but still swollen, siphuncle of a *Suecoceras*, and finally in the tubular siphuncles found in those cephalopods to which the generic names *Cameroceras* and *Foerstella* have been applied.

THE ELLESMEROCEROID COMPLEX

It is necessary to begin the detailed tracing of structural changes with a survey of the ellesmeroceroids, which are properly the ancestors of the endoceroids.

The ellesmeroceroids are primitive cephalopods which were the dominant and perhaps the exclusive representatives of the nautiloids up to the close of the Lower Canadian (Gasconade, Wanwanian), only a few genera and species surviving into later faunas. Although exceedingly variable in form, these cephalopods are readily recognized by their small size, very closely spaced septa, the dominantly compressed section, the attendant development of lateral lobes of the sutures, and the large ventral siphuncle which is devoid of endocones. Much remains to be learned concerning the crucial morphological features of these cephalopods, but many species have been described (Kobayashi, 1933, Ulrich, Foerste and Miller, 1943; Ulrich, Foerste, Miller and Unklesbay, 1944).

Shells of this group exhibit almost every gradation in form from strongly curved endogastric cyrtoceracones to orthoceracones. The shells likewise show all gradations between those which expand very rapidly to those which are essentially tubular. The mature living chamber and apertures may be simple, or may be variously constricted and contracted. The extreme of contraction is reached in ***Buehleroceras*** and ***Burenoceras***, which develop apertures strongly suggestive of the younger ***Phragmoceras***. The section is dominantly compressed, often strongly so. However, some species of ***Ellesmeroceras*** are circular in section, and ***Pachendoceras*** is probably a depressed ellesmeroceroid rather than an endoceroid. The two supposed spicula which have been figured in this genus are open to other interpretations. One is probably adventitious (Ulrich, Foerste, Miller and Unklesbay, 1944, Pl. 64, Fig. 1), and the other (Ibid., Pl. 61, Fig. 4), represents instead the apex of the siphuncle. The sutures may be essentially transverse or may be inclined orad on the dorsal (antisiphonal) side. Lateral lobes are commonly developed, but all gradations between straight and deeply lobed sutures occur, the variation generally corresponding to the development of a compressed cross section.

In spite of wide form variation, the group is a homogeneous one. Many of the species lie so close to the boundaries of the genera as at present defined, that their reference to either one to the exclusion of the other is sometimes extremely difficult. While taxonomic difficulties may easily result, it is clear that the ellesmeroceroids represent a homogeneous but exceedingly plastic group, and one which expanded rapidly in the early Canadian, possibly because it lacked ecological competition.

Attempts to express the diversity exhibited by those cephalopods by the use of several families, have not been very successful. Kobayashi (1933, 1935a) divided these cephalopods into the Plectronoceratidae and Ellesmeroceratidae, apparently mainly on the basis of characters of the siphuncle. He regarded the Plectronoceratidae as varying from orthochoanitic to cyrtochoanitic (Kobayashi, 1933) and the Ellesmeroceratidae as grading from orthochoanitic to holochoanitic (Kobayashi, 1935a). The sections upon which the cyrtochoanitic condition is based are unfortunately rather faint,but the conclusion may be tentatively accepted until better evidence is at hand. Flower (1941a), found ***Ellesmeroceras*** to be aneuchoanitic and not holochoanitic, as Kobayashi believed, a condition which has subsequently been substantiated by unpublished thin sections.

Ulrich, Foerste and Miller (1943) and Ulrich, Foerste, Miller and Unklesbay (1944) divided these ellesmeroceroids into several families on the basis of an exceedingly artificial classification. Orthoceracones were placed in the ill-advised Orthocerotidae, endogastric cyrtoceracones in the Cyrtendoceratidae and straight brevicones in the Cyclostomiceratidae. Flower (1946) pointed out that the cephalopods of the Lower Canadian formed a closely knit group, and the genera distributed among these three families had much more in common, and less in common with other genera placed in those same families, than this current classification would indicate. *Cyrtendoceras* is described as a holochoanitic endoceroid. If so, these endogastric Wanwanian cyrtoceracones should not be placed with it, for they have neither holochoanitic siphuncle walls nor endocones. The family, as thus employed, has no genetic significance. A much closer approach to a taxonomic expression of relationship can be attained by employing the Plectronoceratidae for the endogastric cyrtoceracones and the Ellesmeroceratidae for the orthoceracones of this group. Even so, difficulties are encountered, for there is no clear boundary between these two families. *Eremoceras* and *Ectenoceras* lie essentially upon the tenuous boundary between the orthoceraconic and cyrtoceraconic, and could be placed in either family with about equal justification. For these reasons it seems wisest in the present state of our knowledge to discuss the two families together.

Actual evidence as to the structure of the siphuncles in these forms is very meagre. Kobayashi (1933) published excellent sections of the Manchurian *Multicameroceras*, *Sinoeremoceras*, and *Wanwanoceras*. Unfortunately the limestones showed only rather faint color variation and the photographs were strongly retouched for illustration. Under such circumstances, interpretation of the original structure is extremely difficult. A connecting ring projecting within the siphuncle wall, after the manner of those of *Eothinoceras*, might present a very similar effect without being properly cyrtochoanitic. Unfortunately, it seems necessary to regard with doubt the adoral expanded connecting ring which Kobayashi (1935a) figured for *Plectronoceras*. Ulrich, Foerste, Miller and Unklesbay (1944) suggest that the structure figured may be adventitious and that *Plectronoceras* may have lacked connecting rings. The absence of connecting rings is a conclusion which we are reluctant to accept in view of their universal and very strong development in Lower Canadian cephalopods, but certainly is supported by the present evidence.

The siphuncle wall of *Ellesmeroceras* was figured by the writer (Flower 1941a). The septal necks are very short and are supplemented by thick connecting rings. Possibly some structural differentiation may have taken place within the ring, but the sections studied so far suggest such variation without being clear enough to demonstrate it conclusively. Subsequent thin sections of other species of *Ellesmeroceras* show similar septal necks, but fail to show the original state of the connecting ring clearly. Ulrich, Foerste and Miller (1943, p. 92), have illustrated a very clear section of a *Clarkeoceras*, showing a relatively long septal neck and a thick connecting ring. Except that no zonal differentiation in the ring is indicated, this section is very similar to that of our *Cyptendoceras* shown in Fig. 1c.

The evidence as to the structure of the siphuncle wall in these cephalopods is quantitatively meagre, but indicates aneuchoanitic to rather long ellipochoanitic necks, supplemented by rather thick connecting rings.

Within the siphuncles of some of these cephalopods diaphragms have been reported. The actual evidence of diaphragms is, however, again very meagre. The structures which Kobayashi (1933) figured as pseudodiaphragms in the Plectronoceratidae are so faint that they may well be inorganic. In America, the evidence for diaphragms crossing the siphuncle rests upon a mere handful of specimens. The structure is shown by one specimen of *Stemtonoceras elongatum*, two of *Levisoceras*, sp., and several of *Robsonoceras robsonense*. My own material has so far yielded clear diaphragms only in an undescribed species of *Dakeoceras*. Hyatt (1900) first reported these structures in *Diphragmoceras*, but the type species has never been figured, and only inadequately described. Clarke described diaphragms in *Clarkeoceras newton-winchelli* but Ulrich, Foerste, Miller and Unklesbay reported that the evidence for these structures is inconclusive.

A number of chert internal molds by which much of the American material of Gasconade age is represented, show siphuncle fillings which terminate rather abruptly in bluntly rounded tips. This may signify that infiltration of the matrix into the siphuncle from the living chamber was stopped adapically by a diaphragm, the remainder of the siphuncle being filled only with inorganic calcite and later lost by solution along with the original shell parts. This interpretation is, of course, hypothetical. However, the postulation of diaphragms as an explanation of this phenomenon presents a logical answer to the problem set by these bluntly rounded siphuncle fillings. An organic rather than an inorganic cause is suggested by the occurrence of such abruptly terminated fillings in a group of cephalopods which form both a taxonomic and a stratigraphic unit, the ellesmeroids of the Lower Canadian. Such siphuncles have been illustrated for *Levisoceras*, *Oneotoceras*, *Caseoceras* and the Middle Canadian *Cumberloceras*, and are suggested, though less conclusively, in still other genera.

Admittedly, the meagre data at present do not supply a good basis for understanding the role of diaphragms in growth or function. Good evidence of the structures is so rare that it is uncertain whether they occur only in isolated individuals, whether they developed in only a few species, or whether they may be characteristic of genera which might even be set apart in a family by themselves. Actinosiphonate structure long presented the same problem, and the material by which it could be studied and evaluated was much more abundant than that showing diaphragms.

The limestones in America which yield ellesmeroceroids have not been widely studied faunally. Faunas under investigation by the writer promise to yield much information on the siphuncles of a number of the genera, but in their study the same difficulties are encountered as in the Wanwankou limestone of Manchuria and Korea; color differentiation is faint and makes it difficult to distinguish organic from inorganic features. The ellesmeroceroids clearly fail to show holochoanitic structure, and possess instead short necks and rather dense thick connecting rings. Diaphragms occur in the group, but are rare and of uncertain significance.

The genera which constitute the ellesmeroceroids have been summarized by the writer (Flower, 1946, p. 75–78). They include the Cambrian *Plectronoceras*, the Lower Canadian genera *Shelbyoceras*, *Dakeoceras*, *Burenoceras*, *Buehleroceras*, *Oneotoceras*, *Levisoceras*, *Caseoceras*, *Conocerina*, *Eremoceras*, *Ectenoceras*, *Ellesmeroceras*, *Walcottoceras*, *Robsonoceras*, *Endocycloceras* and *Albertoceras*. *Cumberloceras* and *Smithvilloceras* represent survivals of the stock in Middle and Upper Canadian, and *Cyrtocerina* and probably *Shideleroceras* represent the last survivors of the group persisting to the Richmond. Separate families have been erected for *Buttsoceras*, *Cyrtocerina* and *Shideleroceras*. The proper placing of the remainder in the *Plectronoceratidae* and *Ellesmeroceratidae* must await further study of the structure of the genera.

PROTEROCAMEROCERATIDAE

The family Proterocameroceratidae (Flower, 1946, p. 80), was erected for slender endoceroids with ellipochoanitic siphuncle walls. These are the oldest of the endoceroids and the most primitive. Their slender form sets them apart from the piloceroids, a few of which are also ellipochoanitic. The holochoanitic siphuncle wall distinguishes the Piloceratidae proper as well as the slender Endoceratidae. From the Ellesmeroceratidae the Proterocameroceratidae differ in two respects, the presence of endocones and the differentiation of parts of the connecting ring. The last difference may not be real, but only apparent, for as yet very few ellesmeroceroids have been studied from specimens well enough preserved to show this differentiation should it occur. *Ellesmeroceras bridgei* shows some indication of such specialization in the connecting ring, but the evidence is not conclusive.

Determination of the exact scope of the Proterocameroceratidae requires more information than is now available. Previously it has been assumed that all endoceroids were holochoanitic, and no detailed examination of the siphuncle wall was undertaken. The discovery of aneuchoanitic necks and thick rings simulating necks in opaque section in *Proetrocameroceras*, (Flower, 1941), showed that a careful restudy of endoceroid siphuncle walls would have to be undertaken, preferably by the use of thin sections. Unfortunately this is made difficult by the rarity of suitably preserved material among the older endoceroids. Quite probably the Proterocameroceratidae contain all of the slender endoceroids older than the Chazyan. Certainly all of the Canadian slender endoceroids thus far studied from satisfactory material have yielded ellipochoanitic siphuncles. The number of species and genera which supply this evidence do not, it is true, make a very imposing assemblage. However, the scant evidence is unanimous in indicating ellipochoanitic structure in Canadian endoceroids. The genera in which such structure has been found include *Proterocameroceras*, *Clitendoceras* and *Cyptendoceras*. Suitable material for *Cotteroceras*, *Cyptendocerina*, *Paraendoceras* and *Mcqueenoceras* is not yet available; the extant material of these genera consists of shells which are either chert steinkerns or are extensively dolomitized so that the siphuncle wall is greatly altered. There remain generalized species which have been assigned to *Endoceras*. Sections made from such species indicate that they also are ellipochoanitic and are therefore not properly assignable to *Endoceras* or to the Endoceratidae.

The endoceroids of the pre-Chazyan have been distributed among various genera on the basis of cross section, suture pattern and form. *Proterocameroceras* was shown to be ellipochoanitic (Flower, 1941) and was therefore removed to the Orthocerotidae (Ulrich, Foerste, Miller and Unklesbay, 1944). No species other than the genotype was recognized. Other endoceroids were referred to the Endoceratidae. Straight compressed shells were assigned to *Cotteroceras*. *Clitendoceras* was used for shells which are circular, but have oblique sutures, sloping orad on the dorsum. Perhaps not enough stress was placed on the faint exogastric curvature shown by the genotype. *Cyptendoceras* was employed for depressed shells in which the sutures form ventral and sometimes dorsal lobes. *Cyptendocerina* also has ventral lobes, but the siphuncle is farther from the venter. *Mcqueenoceras* is faintly endogastric, and closely allied to *Clitendoceras*. *Pachendoceras* is employed for depressed shells with a flattened venter and transverse sutures. *Paraendoceras* is distinctive in its rather rapid expansion, approaching some of the more slender shells which have been grouped by Kobayashi with the piloceroids. The more generalized of the species assigned to *Clitendoceras* and *Cyptendoceras* approach very closely to those Canadian shells which have been placed, we think mistakenly, in *Endoceras*. A survey of the Canadian species placed in *Endoceras* shows that not one exhibits evidence of a holochoanitic siphuncle, and many lack evidence of endocones. Many are not true endoceroids, and none are demonstrably members of the Endoceratidae.

It is within the Canadian Proterocameroceratidae that evidence exists of the specialization of the connecting ring and of modifications of the septal neck approaching, but not attaining, a holochoanitic condition.

DEVELOPMENT OF THE SEPTAL NECKS

As previously shown, the meagre evidence indicates that in the ancestral Ellesmeroceratidae the septal necks vary in length, but none have been found which are long enough to be called holochoanitic. The shells which are most similar to the true endoceroids are those of the genus *Ellesmeroceras*, which, indeed, is most readily differentiated from the endoceroid by the absence of endocones. Happily, the actual morphological data is largest for this crucial genus, and indicates uniformly necks so short as to be properly aneuchoanitic. (Fig. 1A).

Within the Proterocameroceratidea, *Proterocameroceras* itself possesses aneuchoanitic necks similar to those of *Ellesemroceras* and *Eurystomites* (Flower, 1941), (Fig. 1B). "*Cameroceras*" *annuliferum* Flower, a species which is probably best placed in the genus *Cyptendoceras*, although it is admittedly generalized in respect to section and sutures, shows short orthochoanitic necks supplemented by connecting rings. *Clitendoceras* has been observed to show a gradual adoral lengthening of the necks in a series of camerae. An undescribed Middle Canadian *Cyptendoceras* (Fig. 1C) shows septal necks which are essentially funnel-shaped rather than tubular. These extend far enough apicad to be at a level with the bend of the next adapical septum, but are so far removed from the septum that the condition escapes being properly holochoanitic. The septal necks of *Coreanoceras* (Kobayashi, 1935) are only slightly longer ventrally. It is perhaps significant that in this genus the condition approaches the holochoanitic without quite attaining it. Further, these same shells, though grouped as piloceroids by Kobayashi, have only moderately expanding siphuncles and phragmocones. In both respects they are intermediate between the Proterocameroceratidae and the Piloceratidae.

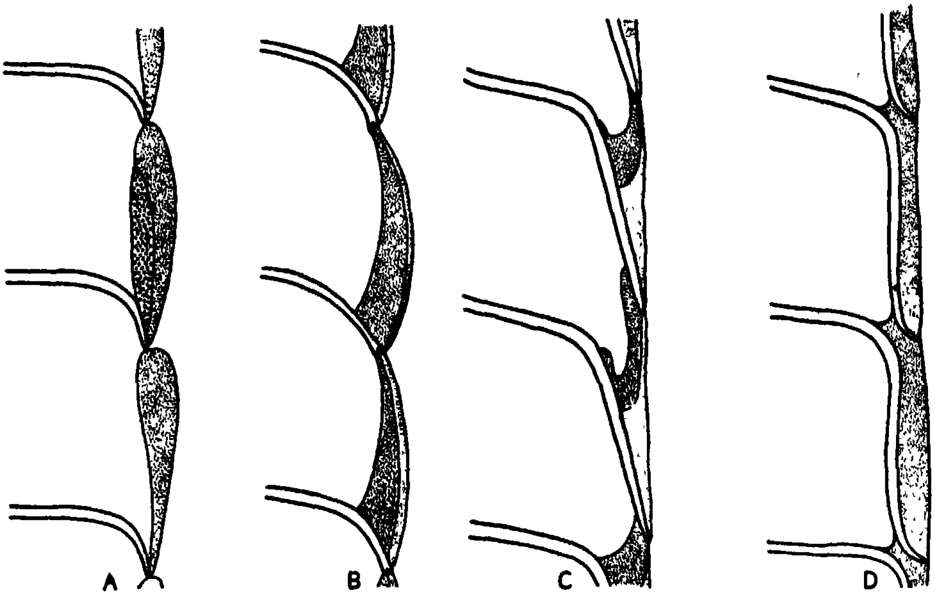

Fig.1. Stages in development of holochoanitic spihuncle wall. A. *Ellesmeroceras*. Aneuchoanitic necks and thick rings. The middle ring shows differentiation of an outer layer suggested by *Ellesmeroceras bridgei* Flower. B. Double layer of connecting ring, as developed in *Proterocameroceras*; based on *P. brainerdi*. C. Intermediate stage, showing incipient concentration of central layer at apex, from *Cyptendoceras*. D. Development of holochoanitic necks, with concentration of dense material making up central layer in B and C at apex, forming eyelet. From *Vaginoceras oppletum* Ruedemann.

THE CONNECTING RING

The progressive series already traced on the basis of the septal neck is supported by stratigraphic evidence, but in itself would be weak without the corroborative evidence supplied by the connecting ring. The ellesmeroceroid-endoceroid line is characterized by connecting rings which are generally and perhaps uniformly thicker than those of the line containing most ellipochoanitic cephalopods. Further, connecting rings of this type show generally some sort of structural differentiation. Two distinct and seemingly diametrically opposed types of structure were found, one in which the connecting ring was divided into an inner and an outer zone, the inner (central) zone consisting of denser and finer grained material than the outer zone. In contrast, a second type was found in which the denser and finer material was concentrated at the tip of the connecting ring. The banded types (Fig. 1B), were first noted in *Proterocameroceras* and in *Eurystomites*, the other type (Fig. 1D), to which I gave the name of eyelet, was found in *Tarphyceras* and in *Endoceras* and *Vaginoceras*. Subsequently it was found in *Cassinoceras*, and there is reason to believe that it is present in *Piloceras* also.

No great taxonomic significance could be given to these diametrically opposed types of connecting rings, for it was obviously unthinkable to unite *Tarphyceras* closely with true *Endoceratidae*, and to unite *Eurystomites* with the endoceroid genus *Proterocameroceras*. To do so would necessitate passing over the strong evidence supplied by section and ontogeny connecting *Eurystomites* and *Tarphyceras* (Hyatt, 1894) and also the evidence supplied by not only form similarity but also the structural patterns of the endosiphuncles of *Proterocameroceras* and the Endoceratidae. Obviously these two types of structure represent variations of a single fundamental structural pattern under the influence of secondary factors which worked indepednently in the Tarphyceratidae and Endoceroidea. Inspection of the nature of the materials of the connecting ring suggests that the central or innermost layer of the zonal pattern is the homologue of the eyelet in the end ceroid pattern. Both consist of dense fine grained to amorphous material, while in contrast the remainder of the connecting ring is crystaline or coarsely granular. Further, the two structures behave very differently under various conditions of preservation. Examples are known of preservation of the eyelet and the inner zone while the remainder of the ring is incomplete or altogether destroyed. When the two types of structure are viewed in relation to the septal necks some suggestion of a solution is found, for the zonal condition is found thus far only in cephalopods with aneuchoanitic necks, but where the septal necks are long, in the connecting ring, which invariably extends from the tip of one neck apicad to the tip of the next, the portion lying within the adapical neck has developed into the eyelet. This is true of *Tarphyceras*. It was not as obvious for *Endoceras*, for the entire length of the connecting ring lies within the next adapical septal neck. Why was not the entire length of the ring given over to structure of the eyelet type? An explanation is suggested by the nature of the materials concerned. If the endoceroids, as was certainly true of many other cephalopods, maintained a connection throughout life between tissues lining the camerae and those occupying the siphuncle, such a connection could have taken place only through a permeable connecting ring. The typical connecting ring was therefore assumed to be secreted within tissue (Flower, 1939), and to maintain a porous character throughout life. As a structure through which such materials must have passed, the ring must remain porous. The eyelet, however, is clearly a part of the ring which is made of dense fine grained amorphous material, which could hardly have been porous. Therefore, it is natural that such material should concentrate in that part of the connecting ring which lay within the next adapical septal neck, where, because of the solid nature of the neck opposing it externally, no metabolic connection existed. Such differentiation of materials may or may not have been completed prior to the perfection of the holochoanitic siphuncle of the Piloceratidae. However, if a metabolic connection between camerae and siphuncle was maintained in holochoanitic shells prior of course to the filling in of the adjacent part of the siphuncle by endocones, such a connection must have taken place through the adoral part of the connecting ring, passing between the septa.

How any such connection was maintained in aneuchoanitic shells with a zonal arrangement of the materials of the connecting ring is uncertain. Either no connection could have existed, or else the inner zone was more porous than was the eyelet. The nature of the material as seen in sections suggests the second explanation, but I do not consider the evidence conclusive. There is no evidence to suggest that the camerae were sealed from the remainder of the shell by delayed secretion of the inner zone; on the contrary, the inner and outer zones were either secreted together, or else the outer zone appeared after the inner one; certainly not before. There is some indication that the outer zone may have thickened by subsequent growth, as suggested by laminae shown in the clearest of the sections. Certainly cameral tissue is a primitive, rather than a specialized, feature and one therefore presumably present in these older cephalopods. The fact that evidence of cameral deposits is nonexistent in the ellesmeroceroids and requires further study in endoceroids before its presence can be conclusively accepted is beside the point.

The faint suggestion of zonal arrangement in *Ellesmeroceras bridgei* Flower (1941a), as indicated in one segment of Fig. 1A, is not conclusive. However, it does suggest that the zonal arrangement is primitive and the eyelet structure developed from it, for the ellesmeroceroids are clearly both older and more primitive than those cephalopods known to show the eyelet.

New material, in the form of a section of an undescribed species of *Cyptendoceras* supplies evidence which forms some basis for this reasoning. The section (Fig. 1C), is intermediate in both the length of the septal neck and the arrangement of the dense material of the connecting ring, between the condition found in *Proterocameroceras* on one hand and that found in *Endoceras* on the other. The septal necks, as already noted, are nearly holochoanitic, but are widely separated because their pattern is conical rather than tubular. The intervening connecting ring is of such a nature that it can be interpreted in terms of either the zonal or the eyelet pattern being an intermediate phase connecting the two. An inner and outer zone can be clearly recognized, but the inner zone is greatly thickened adapically. Likewise, one can interpret the same section as an eyelet which is stretched orad along the inside of the main part of the ring, while the main part of the ring is thickened and somewhat folded around the bend of the septum at its adapical end.

Clear development of the eyelet pattern in an ellipochoanitic endoceroid has not been found. *Cyptendoceras annuliferum* (Flower) showed traces of the eyelet in relatively thick transparent sections. The clarity of the eylet was lost in reduction of the thickness of the section for photography. It is a curious fact that both the eyelet and the perispatial deposits of actinoceroids may be reduced to a point at which they become nearly invisible in the thinnest of sections. Unfortunately they are best displayed in sections thick enough that the contrast between calcite-replaced shell parts and the matrix are so strong that they are not suitable for photography. *C. annuliferum* displays eyelets which are essentially similar to those found in *Tarphyceras seelyi* (Flower, 1941, Pl. 1, Fig. 2, Pl. 1, Fig. 9–10).

While much more remains to be learned about the nature, function and possibilities of radial variation in clarity and distribution of the eyelet in endoceroids, the main point of the structure is that it demonstrated clearly that the connecting ring is retained in the holochoanitic Endoceroidea. This is indicated not only by the phyletic sequence postulated in Figs. 1B-D, but also by the identity of the structure of the connecting ring in *Nanno* and *Vaginoceras* with that of *Centrotarphyceras* (Flower, 1941). Prior to this, the existence of the connecting ring in holochoanitic cephalopods was not recognized. Hyatt (1900) presented a figure of *Endoceras proteiforme* (Fig. 2) showing holochoanitic necks separated by bands which are apparently morphologically distinct from them. The tip of the neck and the tip of this unidentified band are separated by areas indicated in black, which correspond to the eyelet. Hyatt never amplified the complexities of structure indicated in this diagram and his interpretation of these structures is therefore somewhat dubious. However, he never mentioned the presence of a connecting ring. Ruedemann (1906, Fig. 3, p. 413) reproduced Hyatt's figure, and showed a similar structure in *Vaginoceras oppletum* (Pl. 4, Fig. 2–3). This specimen fails to show clearly the differentiation between the septal neck and the connecting ring which arises from its tip. Without this differentiation, the structure seems to be that which Hyatt (1900) had earlier attributed to the genus

Vaginoceras. As a consequence, it is not unnatural that Ruedemann interpreted it as such, and on the basis of this structure assigned his species to the genus *Vaginoceras.* Of the dense and darker colored areas which represent the eyelets Ruedemann says: "The structure of the siphuncular wall, which is here that of a *Vaginoceras*, would suggest that the pseudosepta extend through or caused the collarlike interspace which enters between the septum where it bends into the septal neck and the septal neck of the next younger septum which at this point bends slightly outward." The structures are extremely confusing, and it was not until the species had been examined by abundant thin sections, each of which indicated the same structural pattern, that it became clear that the morphological interpretation must be revised.

The presence of a connecting ring in the holochoanitic Endoceratidae indicates a conclusion already voiced by Kobayashi on the basis of endosiphuncular structures, that the endoceroid was not primitive but highly specialized. Further, it indicated that the endoceroid must have had an ancestry which was ellipochoanitic. Later investigations revealed that this ancestral phase was much more widespread than Kobayashi had realized, for it embraced not only the Plectronoceratidae, which he had shown to have short necks supplemented by connecting rings, but also the Ellesmeroceratidae and the older of the shells which had previously been assigned to the Endoceratidae. This required more a revision of a conception of morphology than one of relationship for, while it was an error to consider the Ellesmeroceratidae and the older Endoceratidae as holochoanitic, the fact remained that the structure of their siphuncle walls was practically identical, and in both groups the thick connecting ring did not simulate a septal neck very closely except in the most favorably preserved material.

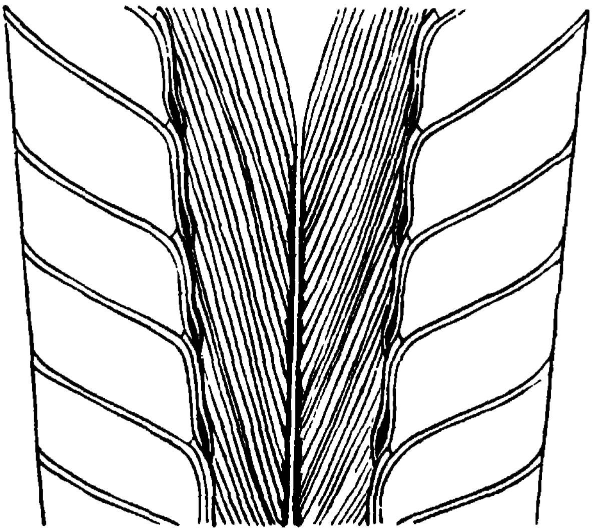

FIG. 2. Section of *Endoceras proteiforme* Hall, after Hyatt. The septal necks are shown as holochoanitic, but supplemented by other unidentified structures which correspond to the main part of the connecting ring. The adapical tips of the rings are shown as separated from the necks by black areas. These represent the eyelets, properly a part of the rings, as shown by thin sections. Within is shown the endosiphuncle, with numerous endocones terminating in an endosiphotube.

Material suitable for a proper study of zonation in the connecting ring of *Ellesemroceras* has not yet been found. *Ellesmeroceras expansum* Flower (1941A, Fig. 1A-B, Pl. 1, Fig. 9, Pl. 2, Fig. 6), shows evidence of some dark material which lies in a few of the camerae between the white calcite which has replaced the connecting ring and the white calcite which forms a chemically deposited filling for some of the camerae. This suggests the possibility of a banding of the connecting ring such as is indicated in text Fig. 1A in the upper complete segment. The transverse longitudinal section of the same species (Flower, 1941A, Pl. 1, Fig. 10), also shows a suggestion of such zonation. However, other parts of the phragmocone lack evidence of these structures and further information is needed. Material of *Ellesmeroceras* from eastern New York has thus far been found to be too extensively recrystallized to yield much additional information.

Where banding is well developed it forms a pattern in which the inner zone is fairly uniform in thickness throughout its length, while the outer zone is widest adapically. This structural pattern is fairly widespread among Canadian nautiloids, and is not by any means confined to the Proterocameroceratidae. It was figured by the writer for *Proterocameroceras* and *Eurystomites*. Ulrich, Foerste and Miller (1943), p. 56, Fig. 3B), have shown the same structural pattern in *Cyclostomiceras cassinense*. Subsequently the same structural pattern has been observed in my own material of *Onychoceras* and *Bassleroceras*. Among orthoconic types it is present in *Baltoceras*, and *Protocycloceras* shows a siphuncle wall which is probably a slight modification of this pattern. Ulrich, Foerste, Miller and Furnish have figured several siphuncles of Canadian nautilicones which appear to have this structure. *Aphetoceras attenuatum*, shown on their Pl. 25, Fig. 6, is very close to *Eurystomites*, although the resemblance is much less marked in the drawing (text Fig. 3, p. 19) of the same section. *Campbelloceras rotundum* (Fig. 10, p. 47, Pl. 50, Fig. 5) shows a suggestion of zonal development, though the irregularity of the structures is again accentuated in the drawing. Here the connecting ring in the ventral siphuncle is so thickened ventrally as to nearly fill the space between the cavity of the siphuncle and the ventral wall of the shell. Such sections suggest that the connecting ring grew after it first appeared by the addition of material to its cameral surface. Whether such deposits of the connecting ring grew outward into the camerae in *Curtoceras* is still uncertain, but such a possibility is strongly suggested by Ulrich, Foerste, Miller and Furnish (Pl. 50, Fig. 3).

Cyptendoceras sp. (Fig. 1C) is thus far the only specimen showing a combination of transitory phases of the septal neck between ellipochoanitic and holochoanitic with a transitory phase between the eyelet pattern and the presumably more generalized zonal condition. Similar conditions are to be expected in some of the Asiatic piloceroids, in particular *Kotoceras*, but the only figure of the siphuncle wall available (Kobayashi, 1936, Pl. 22, Fig. 13), is not enlarged sufficiently to show this. Further, in this specimen, which is an opaque section, differentiation of the septal neck and the connecting ring is not clear.

PILOCERATIDAE

Flower (1941) reported in *Cassinoceras explanator* (Whitfield) structures within the siphuncle which seemed to represent connecting rings, complete with the eyelet, which suggested that the siphuncle was holochoanitic and had essentially the structure observed more fully by means of thin sections in *Vaginoceras oppletum* Ruedemann. Later sections have served to confirm this view. Ulrich, Foerste and Miller (1943) p. 22, found similar structures in *Piloceras invaginatum* Salter, but did not recognize them as connecting rings. They describe them as follows: "The inner surface of the septal necks is lined by a black layer which is about 0.4 mm. thick and which terminates as a thin edge at the adapical end of each neck. The adoral portion of this black layer extends between the adoral end of a septal neck and the adapical end of an adjacent neck for a distance of about 1 mm. along the adoral surface of the septum which gives rise to the adapical neck. Along the inner surface of the siphuncle there is a discontinuous series of these black layers each one 'pinching out' at the adapical end of the septal neck which it lines."

This might almost be a description of the connecting ring shown in Fig. 1D, and there can be little doubt but that it represents an identical structure except that there is no mention of the eyelet. Indication of the eyelet is very plain in *Cassinoceras explanator*.

Happily, the presence of connecting rings within the septal necks in these two species, which are the genotypes of *Piloceras* and *Cassinoceras*, show that the Piloceratidae proper are holochoanitic.

The origin of the Piloceratidae is clearly to be sought in the Proterocameroceratidae itself. Perhaps some of the lesser known slender shells which have been considered piloceroids in Asia may supply the link. *Coreanoceras*, the only member of this group of shells for which the siphuncle wall is known, is ellipochoanitic, as shown by Kobayashi (1935a). This shell is so slender, however, that it seems it might be grouped as easily with the *Proterocameroceratidae* as with the piloceroids; certainly it differs markedly in aspect from the broadly expanded siphuncle of *Chilihoceras*, with which Kobayashi would group it.

It should be pointed out also that we have no evidence as to the position of *Chilihoceras* Grabau, *Manchuroceras* or the closely allied and probably synonymous *Liaotungoceras* Shimizu and Obata in this scheme The endosiphunclar specializations of *Chilihoceras* described by Grabau are so remarkable that other students of cephalopods, who have, it is true, not seen the material, are a bit reluctant to accept the rather complex interpretation of the endosiphuncle which Grabau presents. *Manchuroceras* and *Liaotungoceras* were depressed siphuncles In true Piloceratidae, in which I should include *Piloceras*, *Cassinoceras* and *Allopiloceras*, both the conch and the siphuncle are compressed. The endosiphuncular differences together with the differences in form suggest that the depressed Asiatic genera have undergone a development independent of that of the Piloceratidae, and the two lines may have separated prior to the development of holochoanitic necks. Kobayashi (1935, p. 750), idicates ellipochoanitic necks for the Chilioceratidae, but to the writer it seems unwise to unite the strongly breviconic *Chilihoceras* with the smaller and much more slender *Coreanoceras*, which supplies the only basis for making any statement concerning the siphuncle wall.

ENDOCERATIDAE

While the origin of the Piloceratidae is somewhat obscured by lack of information concerning the structure of possibly crucial genera of Asiatic piloceroids which may supply connecting links with the Proterocameroceratidae, there is enough evidence to show that between these two families occurred the transition from the ellipochoanitic to the holochoanitic siphuncle. The descendants of the piloceroids are easier to trace.

With very few exceptions, it has been seen that the Lower Canadian, with which the Gasconade and Wanwanian are synonymous, contains the acme of the ellesmeroceroids. The Middle Canadian however, shows a maximum development of the Proterocameroceratidae. The Upper Canadian is marked by the piloceroids. The Longview limestone of Alabama furnishes one of the few exceptions. This supposedly Middle Canadian formation contains *Cumberloceras*, which is morphologically a Lower Canadian type, and also *Allopiloceras*, elsewhere confined to the Upper Canadian. Other members of its fauna are essentially Middle Canadian. I have observed similar phenomena, involving a mingling of Lower and Middle Canadian types locally in the Fort Ann region of eastern New York, but closer study has shown that due to deposition of Middle Canadian beds on an uneven erosion surface, in some places fossiliferous Lower and Middle Canadian limestones very similar lithologically, are brought into juxtaposition. So anomalous is the fauna of the Longview that it might be re-examined with this possibility in mind. At present, I am reluctant to accept it as evidence of the appearance of piloceroids in the Middle Canadian.

At the close of the Canadian the Piloceratidae disappear. The Proterocamerocertidae, which dominate the Middle Canadian, persist into the Upper, and become highly specialized, as shown by the siphuncle of ***Proterocameroceras*** itself. Even more bizarre specializations are found in ***Meniscoceras***, the only known survivor of the Proterocameroceratidae in the Chazyan.

The Chazyan marks the appearance of a new stock, the Endoceratidae. This family contains longiconic shells, among which are to be found the largest of our straight cephalopods. They differ from the Proterocameroceratidae and agree with the Piloceratidae in possessing holochoanitic septal necks with the connecting rings within (Fig. 1D). This structural agreement suggests that perhaps the Endoceratidae may have descended from the Piloceratidae rather than from the Proterocameroceratidae which they resemble more superficially. Examination of the morphological facts with this possibility in mind yields some corroborative evidence. The true piloceroids are compressed. Although Endoceratidae are dominantly depressed in section in the adult, the early stages are dominantly, if not uniformly, compressed. Further, among the first of the true Endoceratidae are found those peculiar early stages which have long gone under the generic name *Nanno*. Schindewolf suggested that *Nanno* represented a retention of a preseptal phase, harkening back beyond the point in evolution at which the shell could even be classed as a cephalopod, close to the archetypical mollusc. Yet strangely enough nothing similar to *Nanno* appears in the earlier sediments. *Nanno* ranges from Chazyan to Richmond. The only earlier cephalopod which suggests it at all is the little known ***Mysticoceras*** of Canadian age. Certainly *Nanno* puts in too late an appearance to be interpreted according to Schindewolf's suggestion. Instead, its stratigraphic position suggests that it may represent the recapitulation of a *Piloceras* stage in the development of the Endoceratidae.

Among undisputed Ellesmeroceratidae no apical ends of the siphuncles are known. Enough specimens approach close to the apex to suggest that the siphuncle was small and marginal from its very beginning. ***Pachendoceras***, as noted above, may be an ellesmeroceroid instead of an endoceroid. One specimen (Ulrich, Foerste, Miller and Unklesbay 1944, Pl. 61, Fig. 4), was interpreted as a specimen bearing an annulated endocone. This interpretation is based upon the fact that the apically protruding siphuncle bears annuli which are more widely spaced than are those indicated farther orad by the preserved camerae, or, for that matter, by the adoral part of the siphuncle which extends orad of the camerae. The interpretation of this specimen as an apical end rests upon (1) its small size in relation to other representatives of the species and (2) the fact that septation commonly varies in the early stages of primitive endoceroids, and the difference in spacing of the septa does therefore, not necessarily indicate the conclusion drawn from this specimen by its describers.

In the Proterocameroceratidae a very similar apical end of a siphuncle was described by the writer (Flower, 1941) as "*Cameroceras*" *annuliferum* (Fig. 3D). The nature of the siphuncle wall proclaims this form a member of the Proterocameroceratidae. Subsequently collected material from the type locality indicates that the species is rather generalized in form, but is close to some of the more generalized species which have been assigned to *Cyptendoceras*. Further, a similar small siphuncle has been found in the early stages of an unquestionable *Cyptendoceras* from the Fort Ann region. Both specimens show a siphuncle which contracts slowly toward its tip, and in both there is the faintest suggestion of a very tiny apical bulbous inflation. These facts are significant to the present discussion mainly in indicating that in the Lower and Middle Canadian Ellesmeroceratidae and Proterocameroceratidae there is no indication of a siphuncle which expands rapidly and may even occupy the entire diameter of the apical part of the shell.

Apices of siphuncles are well known in the Piloceratidae, but are invariably free from the phragmocone. Here both the phargmocone and the siphuncle expand very rapidly. Although the camerate region of the shell is very tiny in the apical region, the evidence suggests that in all three of the genera the phragmocone extends very close to the apex, if not completely to it. (Fig. 3A.)

The next stage in development is marked by a tendency for the adoral part of the siphuncle to become slender. Sometimes the siphuncle assumes a more slender form gradually, but in a few species the transition is abrupt. Further, in these same species there is only poor and inconclusive evidence of septation on the outside of the siphuncle; such faint annuli as exist may be septa; on the other hand similar markings would be expected as relics of septa in shells in which the siphuncle has expanded so as to crowd out the camerae completely. Although such a conclusion is somewhat venturesome, I have indicated it in my interpretation of *Allopiloceras* (Fig. 3B), based upon a specimen of *A. sevierense* (Ulrich, Foerste and Miller, 1943, Pl. 3, Fig. 4), and have ventured to reconstruct a hypothetical phragmocone and living chamber for this species.

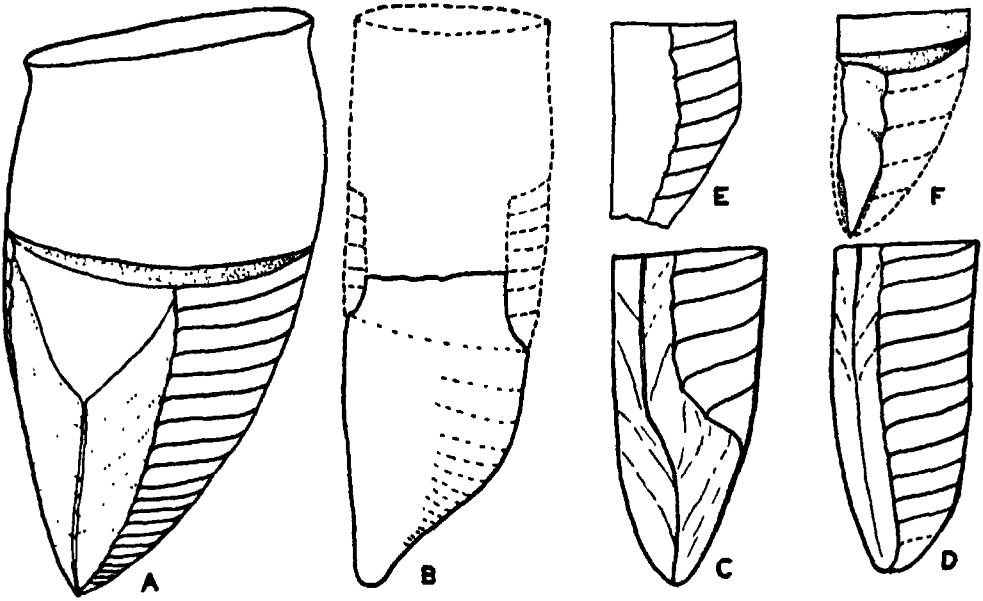

FIG. 3. Apical condition of siphuncles in endoceroids. A. *Cassinoceras*, with entire phragmocone expanding rapidly, but marked acceleration in expansion of siphuncle beyond that of the conch. B. *Allopiloceras*, based upon the specimen of *A. sevierense* showing the most marked adoral contraction of the siphuncle. Phragmocone and living chamber reconstructed. C. Vertical section through *Nanno*, based upon *N. noveboracum* Ruedemann. D. Apex of *Cyptendoceras annuliferum* (Flower). E. *Suecoceras*. F. Apex of *Endoceras*, based upon specimens currently assigned to *Cameroceras trentonense*. Shell restored over apex.

If such an apex is reduced in size, and the slender siphuncle indicated in this *Allopiloceras* is continued through a series of camerae in a slender phragmocone, a condition is developed which is essentially that of *Nanno noveboracum* Ruedemann (1906) of the Chazyan limestone (Fig. 3C). On this basis it is possible to explain *Nanno* as a recapitulation of a *Piloceras* stage, and the Piloceratidae-Endoceratidae sequence as a palingenetic one. *Nanno* persists into the Richmond, where a number of fine siphuncles, soon to be described, have been found. Some of these are startingly similar in proportions to those siphuncles which Holm (1896,) figured for *Nanno belemnitiforme* of the *Orthoceras* limestone of Sweden.

Continuation of the tachygenetic sequence would explain *Suecoceras* (Fig. 3E), as a slight reduction of the *Nanno* phase; the apex of the siphuncle is still swollen and then contracted into a slender tube, but septation reaches the apex of the conch. Reduction of the swelling produces the apical ends which have been known as *Cameroceras* (Fig. 3F), and *Foerstella*. The genotype of *Foerstella* shows by the structure of the siphuncle wall that it is a true member of Endoceratidae. I have as yet had no material for sections of the type of *Cameroceras*, but there can be little doubt but that *Cameroceras trentonense* is nothing more than the apical stage of several species of *Endoceras* which occur as adult shells, though devoid of the apex, in the same beds. Among these forms is *Endoceras proteiforme*, the genotype.

Features of the endosiphuncle remain fairly uniform in the Endoceratidae, and differ from those of the Piloceratidae only in the simplification of the form of the endocones, which lack the wrinkling sometimes found in *Cassinoceras*. No important difference is to be found in the siphuncle walls between the two families. Yet the differences in shape are so great that the relationship was not previously suspected. However, it is now apparent that not only are there strong structural bonds uniting these two families, but that the slender endoceroids of the Canadian, which resemble the Endoceratidae superficially, differ from them widely in structure.

CONCLUSIONS

The morphological evidence yielded by thin sections of siphuncle walls shows that the holochoanitic type of structure is not dominant in a large group of cephalopods of which the endoceroids are a part, but instead is a specialization which is developed only in a small and highly specialized group of the Endoceratida, comprising the families Piloceratidae and Endoceratidae. The beginning of the stock is to be found in the oldest of our cephalopods, the ellesmeroceroids, which lack endocones, occasionally possess diaphraghms, but possess short septal necks supplemented by thick connecting rings. The Proterocameroceratidae, the first and simplest of the true endoceroids, differ from the ellesmeroceroids mainly in the addition of endocones to a shell which is otherwise essentially that of an ellesmeroceroid. Within the Proterocameroceratidae two trends are evident, first, the differentiation of parts of the connecting ring, producing either a zonal pattern or an eyelet. Happily connecting links are found showing that the two structural types are closely related. Second, in this family there is a tendency toward elongation of the septal necks. Necks long enough to be holochoanitic are found first in the Piloceratidae, accompanied by connecting rings, clearly a heritage from their ancestors of the Proterocameroceratidae. The rapid expansion of the piloceroid shell is necessarily coenogenetic. The Endoceratidae of the Ordovician are descended from the Piloceratidae with which they agree in the holochoanitic siphuncles retaining connecting rings. The rapid expansion of the siphuncle and the compressed condition of the piloceroid are recapitulated in the early stages of the Endoceratidae as shown by *Nanno*. Tachygenetic reduction of this stage produces more generalized early stages typified by *Cameroceras* and *Foerstella*. In gross features such apical ends resemble those of the Ellesmeroceratidae and Proterocameroceratidae, but differ from them in the holochoanitic septal necks.

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Reptiles and Amphibians of the Northeastern States

Ohio naturalists will be interested in obtaining the recently published booklet, Reptiles and Amphibians of the Northeastern States, written by Roger Conant, who is also the author of the standard reference, "Reptiles of Ohio." Formerly curator of reptiles at the Toledo Zoo and now curator of the Philadelphia Zoological Garden, Conant has written this 40-page non-technical resume as a publication of the Zoological Society of Philadelphia for the benefit of nature enthusiasts of that region. It deals with the snakes, lizards, turtles, frogs, toads, and salamanders of the northeastern states from Maine through New York, Pennsylvania and Maryland, and the coastal plain region of New Jersey and Delaware. Each of the 86 species listed is described briefly and is illustrated in a clear black-and-white photograph. Many of these photographs will suffice for identifying specimens. Photographs of juvenile snakes and turtles are given when such juveniles differ in pattern from their adults. In addition to the species' description, each group dealt with carries a short, well-written article on various phases of its biology. Also, there are directions for giving first aid in snake bite, and for the care of captive specimens. No taxonomic keys are included, but there is a useful reference list to more technical works. Although this booklet deals with the herpetological fauna from Pennsylvania eastward, it includes the majority of such species usually collected in Ohio, particularly in the eastern portion of the state. This booklet should find extensive use in the hands of high school biology students, scout organizations, and field naturalists throughout this entire region.—*John W. Price.*

Reptiles and Amphibians of the Northeastern States, by Roger Conant. Zoological Society of Philadelphia. 40 pp., 9x11¾ in. 1947. Price $1.00.

SPIROGYRA HOLLANDIA, A NEW SPECIES FROM NEW GUINEA

CLARENCE E. TAFT,
The Ohio State University

The type material was collected at Hollandia, Dutch New Guinea, by Mr. Robert Sigafoos, now at the Harvard Biological Laboratories. Collections from Biak, Dutch New Guinea, made by Dr. M. E. Britton, Northwestern University, established the limits of variability of the species as it is now described.

The writer expresses his appreciation to Mr. Sigafoos and Dr. Britton for the material, and to Dr. E. N. Transeau, Professor Emeritus of this department, for his criticisms and for the use of his unpublished monograph on the Zygnemataceae which made possible the segregation of the species.

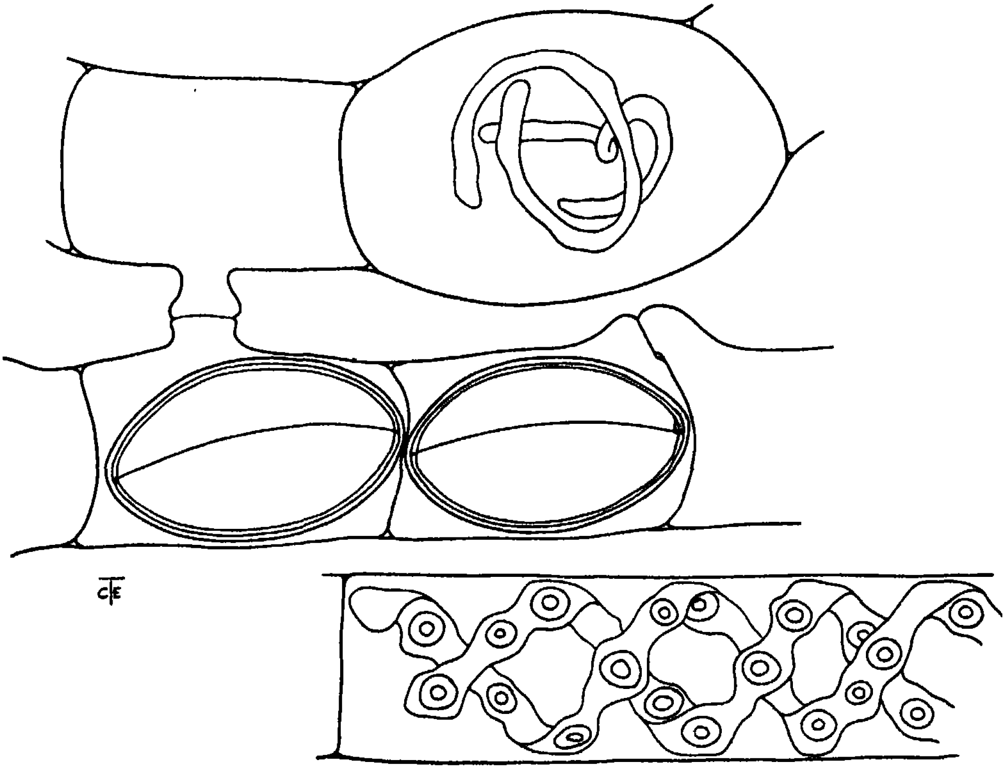

FIG. 1. *Spirogyra hollandia* sp. nov. Conjugating filaments showing lateral and scalariform conjugation, mature zygospores and a sterile cell. A portion of a vegetative cell is also shown.

Spirogyra hollandia sp. nov.

Vegetative cells 36–41μ x 60–192μ with plane end walls; 2 chromatophores, broad with large pyrenoids, making 1.5–2.5 turns in the cell; conjugation usually lateral, rarely scalariform; tubes formed by both gametangia; sterile cells sometimes inflated; receptive gametangia clyindric or enlarged; zygospore ellipsoid with rounded ends, 38–42μ x 62–78μ, median wall smooth, bright yellow at maturity.

Dutch New Guinea: Hollandia (Robert Sigafoos Coll.): Biak (M. E. Britton Coll.).

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[1] Paper from the Department of Botany, The Ohio State University, Columbus, Ohio. No. 498.

NEW BUPRESTIDAE WITH NOTES (COLEOPTERA)

JOSEF N. KNULL,
The Ohio State University[1]

Acmaeodera fisheri vermiculata n. var.
(Fig. 7)

Male.—Size and form of *A. fisheri* Caz.; head and pronotum dark bronze, elytra yellow with dark brownish bronze maculations forming irregular lines; ventral surface obscured by white tomentum.

Head convex, surface densely, lightly punctured, obscured by long pubescence; antennae extending past middle of pronotum when laid along side, serrate from fifth segment.

Pronotum wider than long, widest back of middle, wider at base than at apex; side margin broadly rounded; anterior margin broadly lobed in middle; basal margin obliquely truncate from each side; disk convex, slight depression in middle at base; surface with densely placed large shallow punctures which are more numerous at sides, moderately clothed with long fine pubescence which is intermixed with white flocculent scales at edges.

Elytra at base not as wide as widest part of pronotum; sides expanded back of base, constricted in front of middle, expanded back of middle then broadly rounded to rounded, serrulate apices; disk convex, umbone prominent, depression at base; surface striately punctured, punctures less than their own diameters apart, interspaces minutely punctate, an upright hair arising from each.

Abdomen beneath finely, densely punctured, punctures hidden by tomentum, last abdominal segment very broadly rounded, lacking carina. Prosternum retracted, anterior margin straight.

Length 6 mm.; width 2.1 mm.

Female.—Somewhat stouter than male; last ventral abdominal segment more acutely rounded; outer antennal segments less transverse.

Holotype male labeled Palm Springs, Calif., June 30, 1946, allotype same locality, June 20. Paratypes from same locality and dates, also June 30 and July 9, 1941, all collected by D. J. & J. N. Knull; Phoenix, Ariz., May 24, 1936, R. H. Crandall. All in collection of writer. Also twenty miles east of Mesa, Ariz., June 11, 1942, Van Dyke[2] collection, California Academy of Sciences and Bill Williams Fork, Ariz., June 5, 1937, W. Benedict collector, in collection of University of Kansas.

At first I was inclined to consider this form a distinct species. Further study convinces me that it is a variety of *fisheri* Caz. which varies with immaculate elytra.

Dr. E. C. Van Dyke has kindly compared it with type of *A. vanduzeei* Van D. and states: "It is shorter and stubbier, *vanduzeei* being longer, 8 mm.; narrower and more attenuate posteriorly; anterior clypeal margin more widely, less angulately incised at middle; pronotum but little wider than elytra, moderately arcuate laterally while in *vanduzeei* considerably wider than elytra with sides much more evidently arcuate and pronotum in latter more coarsely, closely and deeply punctured; elytral markings of new species more or less opaque black and somewhat lineate in arrangement, while in other decidedly bluish, shining and more irregular in arrangement much as in *A. labyrinthica* Fall; punctate striae also more deeply impressed."

Dicerca strandtmanni n. sp.
(Figs. 5 and 6)

Female.—Resembling *D. divaricata* (Say) in color and form without prolonged apices of elytra.

Robust; color cupreous bronze throughout; pubescence inconspicuous above, longer beneath and on legs.

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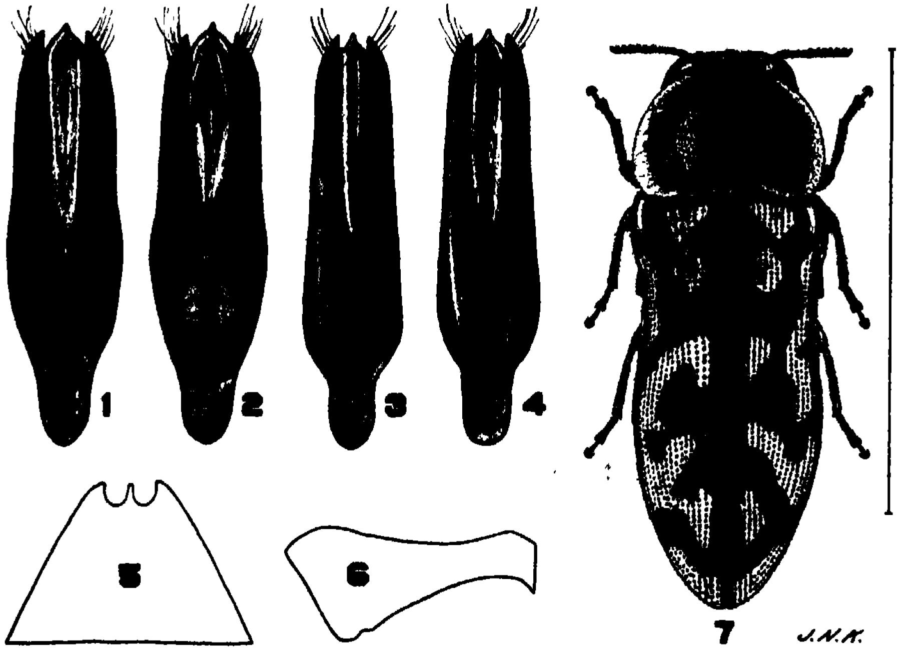
[1] Contribution from Department of Zoology and Entomology.

[2] The writer is indebted to Drs. R. H. Beamer and E. C. Van Dyke for the loan of material.

Head with front concave, surface irregularly, coarsely punctured; antennae not extending beyond middle of pronotum when laid along side, serrate from fourth segment.

Pronotum much wider than long, widest in middle, wider at base than at apex, side margins diverging to middle, then rounded, subparallel near base, margin carinate at base; anterior margin strongly sinuate; basal margin slightly sinuate; disk convex, with median depression and small transverse depression in front of scutellum; surface coarsely irregularly punctured, forming irregular smooth areas, punctures sparse on both sides of middle. Scutellum round, depressed in middle.

Elytra at base wider than widest part of pronotum; sides subparallel near base, expanded back of middle, then broadly rounded, sinuate near apices which are somewhat produced and truncate, suture prolonged into a small spine; disk convex, a basal depression each side at umbone; surface coarsely irregularly punctured, with irregular depressed areas of dense punctures between smooth areas; punctures in rows along suture, suture carinate posteriorly from beyond middle.



1. *Buprestis nuttalli* Kby., ♂ genitalia, dorsal view. 2. *Buprestis nuttalli* Kby., ♂ genitalia, ventral view. 3. *Buprestis consularis* Gory, ♂ genitalia, dorsal view. 4. *Buprestis consularis* Gory, ♂ genitalia, ventral view. 5. *Dicerca strandtmanni* n. sp., ♀ last ventral. 6. *Dicerca strandtmanni* n. sp., posterior coxal plate. 7. *Acmaeodera fisheri vermiculata* n. var., ♂, (line equals 5 mm.).

Prosternal process flat, smooth, sparsely punctured. Hind coxae with posterior margin slightly sinuate internally, outer angle prolonged. Abdomen beneath coarsely, irregularly punctured, fifth ventral as illustrated, Figure 5.

Length 19.5 mm.; width 7.4 mm.

Holotype female in collection of writer labeled Texas, 1929, R. W. Strandtmann collector.

This species differs from other closely related members of the genus by truncate elytral apices, mucronate on inside, flat prosternal process and prolonged outer angle of posterior coxa.

It is possible that this may be a female of *D. mutica* Lec. Van Dyke[3] decided that *mutica* was a deformed specimen of *lurida* (Fab.).

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[3] E. C. Van Dyke, Ent. News, 45, p. 91, 1935.

Buprestis prospera Csy.

This is a valid species. As pointed out by Casey[4] the intervals are more coarsely, confusedly, densely cribrate than *B. aurulenta* L. In addition the last visible ventral segment of abdomen is more broadly truncate in both sexes. Specimens are at hand from Arizona: Williams and south rim of Grand Canyon; New Mexico: Jemez Springs.

Buprestis consularis Gory

(Figs. 1, 2, 3 and 4)

An examination of the male genitalia convinces me that this species is distinct from *B. nuttalli* Kby. In addition to shape, the latter has a rugose area on ventral surface of genitalia near base.

Agrilus masculinus Horn

Adults reared from dead branches of Ohio buckeye (*Aesculus glabra* Wild.) collected in Delaware Co., Ohio, have vertex and pronotum brilliant cupreous, elytra black.

Agrilus champlaini Frost

This species makes galls on living blue beech (*Carpinus caroliniana* Walt.) in Crane Hollow, Hocking Co., Ohio. The swellings are similar to those formed on ironwood.

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[4] T. L. Casey, Proc. Wash. Acad. Sci., 9, No. 2, p. 122, 1909.

The Eye-Bank for Sight Restoration, Inc.

Extensive ophthalmic research which some day may enable many of the blind to see again, and will contribute greatly toward the prevention of blindness, is now under way in the laboratory of The Eye-Bank for Sight Restoration, Inc., at its national headquarters, 210 East 64th Street, it was disclosed here recently by Mrs. Aida de Acosta Breckinridge, Executive Director.

Although one of the principal objectives of the research carried on at the present time is the discovery of a method for the preservation of corneal tissue over a longer period of time than 72 hours, a variety of other problems in the field of ophthalmology are also being studied, according to Dr. Herbert M. Katzin, who is in charge of the laboratory.

During the past year, the Eye-Bank has granted seven fellowships for research and sixteen scholarships for its training course in the operation for the transplanting of healthy corneal tissue to blind persons who lost their sight because of corneal defects. Dr. Katzin has been developing special teaching methods to give surgeons the knowledge and skill required for this delicate operation.

Typical of the research projects carried on in the Eye-Bank's laboratory are studies to improve the surgical technique of corneal grafting and to perfect photographic methods for recording purposes; development of newly discovered properties of beta radiation in treatment of corneal scars; study of the use of physiological fibrin as a substitute for sutures, and development of methods for transplantation of the vitreous.

The technique of the corneal-graft operation which is taught and constantly perfected at the Eye-Bank has attracted such world-wide attention that it is beginning to serve as an institute for foreign ophthalmologists who wish to specialize in this field. Physicians from other countries who have come here and have had scholarships or fellowships from the Eye-Bank include:

Dr. John D. Blum, Geneva, Switzerland; Dr. Walter Kornbleuth, of the Hebrew University of Jerusalem; Dr. Geniniano de Ocampo, Manila, instructor in Eye, Ear, Nose and Throat at the Philippine General Hospital; Dr. M. K. Yue, Fukien, China; Dr. P. K. Kuo, Shanghai, China; Major M. M. A. Dubash, Bombay, India.

The operation substituting a healthy cornea for a damaged one can restore sight in only one type of blindness—that caused solely by opacity of the cornea when the rest of the eye and optic nerve are normal. It is estimated that 15,000 of the 250,000 blind persons in the United States can benefit from the corneal-graft operation.

More than a hundred leading hospitals throughout the country and many of the nation's outstanding eye surgeons are affiliated with the Eye-Bank. It is being greatly assisted by the co-operation of the Red Cross Motor Corps and important airlines in transporting eyes to the Eye-Bank and to hospitals.

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ANTIBIOSIS[1]

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The term antibiosis, which is the title of this paper, may to many biologists be a rather new term that has been in frequent use only since the discovery of penicillin in 1929. But in reality it is a term used by botanists for a long time. It seems to have been coined by H. M. Ward (1) in an article on Symbiosis published in Annals of Botany in 1899. The more familiar term "symbiosis" has long denoted the partnership of two organisms, often of different type, for their mutual benefit. An example is the common root tubercle bacteria which live in the nodules on the roots of peas, clover, etc. Here the bacterial cells get a favorable place to live and in turn their work of storing up compounds of nitrogen, later enriches the habitats of their hosts. In the article referred to above Ward said, "Where one of two associated organisms is injuring the other . . . this state of affairs has been termed antibiosis."

This harmful relationship was studied more thoroughly by the German writer, J. Behrens (2), in 1904 in a paper entitled "Alteration Effects between Different Organisms," which appeared in the Handbook for Technical Mycology at Jena. In this article Behrens discussed symbiosis, metabiosis and *antagonism* between organisms. Dr. Erwin F. Smith (3) of the U. S. Department of Agriculture in 1905 published studies along similar lines in his article, "Bacteria in Relation to Plant Diseases." The earliest detailed work done on this subject was done in the 1890's by a French bacteriologist, C. Bouchard, and others in Europe. The entire literature in the field has recently been surveyed by Dr. Selman A. Waksman (4), the discoverer of streptomycin, who has been extremely kind and helpful to me in the preparation of this paper. He and his colleagues at Rutgers have reviewed over 1,000 articles dealing with antibiosis and I shall quote briefly the chief references in this early work. "Bouchard (5), Emmerich and Low demonstrated that certain bacteria belonging to the *Bacillus pyocyaneus* group have the capacity of inhibiting the growth of other bacteria and of actually killing these organisms. This was found to be due to the production of a substance designated as *pyocyanase*, the first antibiotic substance ever described. However, this phenomenon was looked upon rather as a freak, the substance being regarded as an enzyme that had the capacity of bringing about the lysis of certain bacterial cells. The plant pathologists constantly observed in their cultures of fungi and bacteria, the detrimental action of one organism upon another, but they were satisfied to designate this phenomenon as one of "staling" without attempting to uncover the manifold reactions involved. The soil microbiologist, in his studies of mixed populations of micro-organisms, long recognized the fact that one organism may affect, to a marked degree, the activities of another, but he dealt with such a highly heterogenous medium, the soil, that his problem appeared hopelessly complex. By designating as "soil toxins" the injurious substances thus produced he failed to succeed in unravelling further the complicated reactions involved. The chemist isolated and even crystallized certain antimicrobial substances produced by bacteria, such as ***pyocyanin*** and by fungi such as ***penicillic acid*** and ***gliotoxin***, but even then the practical utilization of these substances was hardly comprehended. Only isolated investigators recognized the great possibilities involved in the antagonistic inter-relations among micro-organisms and drew attention to their possible applications. This was first done by Pasteur and Joubert in 1877, followed by Cantani in 1885, by Bouchard, Emmerich and Low in 1889, by Vaudremer in 1913, by Much in 1924, by Fleming in 1929 and finally by Dubos in 1939. It remained for the last half decade to uncover the great potentialities of this highly important field of microbiology with its many phases touching upon Chemistry, Physiology, and Chemotherapy." In concluding this review of the history of antibiotics, I might say that the last named student in this field, Dr. R. J. Dubos, a colleague of Waksman's at Rutgers and now at Harvard, has in the period between 1929 and 1944 published 19 papers, and Dr. Waksman himself, 38 papers, on this subject in various medical, chemical, and biological journals. This indicates the great activity in this field today.

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[1] **Presidential address, delivered before the Ohio Academy of Science at Marietta, Ohio, May 2, 1947.**

ORGANISMS IN THE SOIL AND THEIR INTERRELATIONS

Since most of the antibiotic substances in use today as therapeutic agents have been isolated from organisms which inhabit soil, it is now appropriate to examine this complex thin layer of the earth's surface.

Waksman and his associates have made thousands of analyses of soil, both biologically and chemically. Dr. Charles Thom (6), a specialist on molds in the U. S. Department of Agriculture, has said, "a teaspoonful of soil contains hundreds of millions of bacteria, millions of actinomycetes, hundreds of thousands of mold spores, tens of thousands of protozoa and hundreds of nematode worms. In such an environment a delicate, soft-walled plant like ***Penicillium notatum*** needs protection comparable to a tank in human warfare."

Looking first at the chemical composition of the soil it is chiefly a mass of inorganic particles of sand, clay, and pulverized rock, which constitutes 90 to 99 per cent of its volume. The organic matter in the top layer of soil varies from 1 to 10 per cent, although in dry desert and sandy soils the organic part may be less than 1 per cent and in peat and muck soils it may be increased to 50 or even 90 per cent. Contrary to what one might expect the organic or humus part of the soil is not mainly cellulose or hemicellulose which occurs in plant bodies but is high in lignin and protein content. These substances are less amenable to microbial action than the actual bodies of plants and animals. To a large degree this black mixture is soluble in alkalies and can be reprecipitated by acids. Collectively these substances have been termed "humic acids." The chief mineral components of average soils are the phosphates, sulfates and silicates of calcium, magnesium, potassium, iron, aluminum, manganese, zinc, copper and others. Some of the chemical elements derived from these minerals are utilized by organisms to make protoplasm and food such as nitrogen, sulfur and phosphorus. Others as zinc, copper, iron, manganese, boron and even potassium may serve as catalysts in life processes. The functions of these latter elements are as yet little known in the metabolism of living things. The top region of the soil in which the root systems of higher plants live is called the rhizosphere and it is in this layer that most of the biological activity of the soil occurs. It is here that the millions of organisms live as mentioned by Dr. Thom. Most of these microbial organisms are supported by the wastes or debris of the bodies of higher plants and animals that live on the surface of the earth. Some of the minute forms of life, living in the soil, are also dangerous enemies of the higher organisms that are on the surface. These are exemplified by the root-rots, blights and wilts that attack crop plants as well as bacteria and fungi that can attack animals and men as the tetanus and botulism organisms, pathogenic yeasts and molds. Certain pathogens which normally live only in the bodies of higher animals may temporarily live in the soil having been deposited there with wastes. These may later reinfect other animals. Waksman classified the microbial denizens of the soil into eight groups, viz.: bacteria, actinomycetes, fungi, algae, protozoa, worms, insects and near-microscopic forms, and ultra-microscopic forms such as viruses and phages.

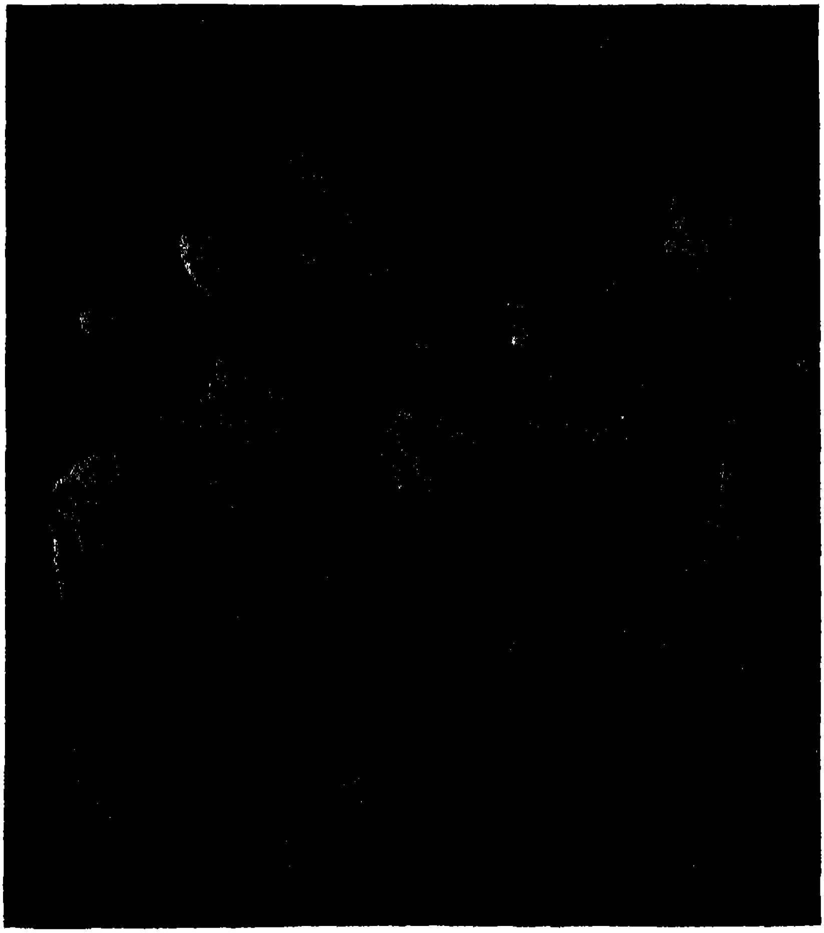

FIG. 1. Dr. Selman A. Waksman.

The relative abundance of the above organisms is dependent on the nature of the soil, the amount of organic matter in it, the oxygen supply, the moisture content, the temperature, and the buffer capacity—and also the type of the higher plants growing in the area. The bacteria, actinomycetes and true fungi run into the thousands per gram of soil. Algae are numerous only in the surface layer of soil. Protozoa are found in the active state or in the form of dormant cysts. This depends on the moisture content. Sometimes the protozoa only are in the active stage for a few hours during excessive moisture while the encysted forms occur almost uniformly in dry soils. The commonest protozoa in soil are the flagellates which may reach a population of a million individuals per gram of soil, the amebae are next in abundance and the ciliates, the fewest, numbering a few hundred to several thousand per gram of soil. The nematode worms, rotifers, earthworms and insect larvae are usually abundant.

The bacteria are of various types based on their nutrition, respiration and motility. They may be autotrophic, heterotrophic, aerobic or anaerobic,motile and non-motile, pathogenic and saprophytic, symbiotic and non-symbiotic, antagonistic and non-antagonistic. The fungi are classified into three types: saprophytic and free-living, mycorhiza-producing, and plant pathogenic. The commonest genera of soil fungi are these: ***Rhizopus*, *Mucor*, *Penicillium*, *Aspergillus*, *Trichoderma*, *Fusarium*, *Cladosporium*** and ***Cephalosporium***. There are also numerous yeasts and fleshy or mushroom types of fungi. The mycelia of these latter fungi spread extensively through the soil and hold it together in masses.

It is now recognized that all the higher plants and animals suffer from the ravages of microbes such as bacteria, fungi and protozoa; and the more highly evolved the plant or animal, the more numerous are its microbial parasites. Many of these disease-producing agents are closely related to harmless forms which lead independent lives in soil or water. This leads to the assumption that the disease-producing agents were once non-pathogenic but which became adapted to a parasitic life in specific hosts. In such hosts these agents produce toxic substances which injure the host for a greater or shorter period until the host succeeds in building up a resistance to the pathogen or it is finally killed by it. If the host survives the attack, however, without killing its parasite, it may regain a normal life but is henceforth a carrier of the pathogen. These disease-producing organisms spread from host to host through natural media as water, dust or excreta of the host and so reach the soil or water.

When one takes into account the great length of time that plants and animals have lived on the earth and the millions upon millions of disease-producing organisms which caused their deaths and then passed into the soil and water with their disintegrating host, it would be logical to conclude that the soil and water of the earth are the great repositories of disease-producing microbes. This was the opinion of the scientists of the 19th century. But careful investigation of soils and waters show that only a few forms which would attack men or animals live in these media. It was furthermore found that pathogenic organisms that kill their hosts, when followed directly into the soil or water, do not live long and disappear rapidly. Researches on soil showed that if it is actually sterilized and then some pathogens inoculated into it, they may flourish there, but if these same pathogens are planted in fresh soil, they die quickly. Thus it is seen that the natural soil and water of the earth are not great repositories of disease-producing organisms but that just the opposite prevails. Ordinary soil by reason of its own normal microbial population destroys any pathogens which find their way into it. It has been found that even the common ***Rhizobium***, a bacillus that forms nodules on the roots of leguminous plants, cannot thrive outside the nodules of the roots. Waksman (7) found that the normal soil microbes will quickly kill it when it is placed alone in soil. It survives only when protected in the security of its nodules on the plants. Another instance is the case of the Texas Cattle Fever organism. This lives in pastures of the southern states. Smith and Kilbourne (8) showed this organism to be a protozoan which is inoculated into the cattle by a tick which is a carrier for the parasite. This protozoan is not able to live in climates which are cold enough to kill the ticks. Thus it is seen that it cannot survive in the soil of the pasture unless it is protected in the body of the tick.

ORGANISMS PATHOGENIC FOR MAN

Briefly at this place let us pause to look at the micro-organisms which may produce diseases in man. These small forms are found in both the plant and animal kingdoms. In the latter belong the Protozoan parasites which infect man inside his body or on the surface. In this group fall the amebae, which live in his intestine or in the mouth, the malaria which devour his red corpuscles, the flagellates which may live in the genital tract or the trypanosomes that cause sleeping sickness in nervous tissues and the ciliate, *Balantidium*, that infects the colon. But by far the greater number of his ills are due to plants which are parasitic members of that great group comprised under the vague term of Mycetes or Fungi. This poorly defined and mixed aggregation includes the Schizomycetes or Fission Fungi and the Eumycetes or True Fungi. The Schizomycetes are made up of three smaller groups; 1, the Eubacteriales or True Bacteria; 2, the Spirochaetales; and 3, the Actinomycetales. The True Bacteria are now pretty well defined and contain most of the familiar bacilli, cocci, and spirilla. The latter contains the *Vibrio* that causes Asiatic Cholera. The second group, Spirochaetales, may have descended from protozoa. It includes the Syphilis organism, *Treponema*. The third group, Actinomycetales, is supposed to have descended from the true fungi, are called the Higher Bacteria. One division of it—the Mycobacteria—includes the organisms that produce tuberculosis, leprosy, and diphtheria. The other division of the Actinomycetales consists of harmless soil organisms, some of which furnish antibiotics like streptomycin.

FIG. 2. Streptomycin crystals. (× 350.)

Associated with the True Bacteria are the Rickettsias, which seem to be very small forms that may have evolved from regular bacteria and have become pasasites such as cause Typhus Fever and Rocky Mountain Spotted Fever. Besides these there is the large group of viruses. These are so small they can pass through fine porcelain filters and bacterologists have not determined whether they themselves are organisms or some product of organisms like enzymes. They differ in character from bacteria and fungi but are definite entities which produce such diseases in man as rabies, smallpox, yellow fever, parrot fever, chickenpox, German measles, mumps, infantile paralysis, influenza and common colds, and herpes or cold sores. These viruses are smaller than rickettsias and cannot be grown on culture media unless living cells are also present. They multiply only in young living susceptible cells, where they live like intracellular parasites. Their presence is indicated by tiny particles of uniform size in the cytoplasm of the cells. These are called inclusion bodies of virus bodies and have been isolated by centrifugation and studied in the production of vaccines.

Before leaving the subject of classification of pathogenic organisms it will be well to mention an artificial classification in the true Bacteria which divides them all into two important physiological classes. These two artificial groups are formed by a simple staining technic used by bacteriologists called Gram's Stain. A dried film of bacteria on a glass slide is stained with a violet analine dye, next this is treated with a solution of iodine and iodide. The dye is removed by immersion in alcohol to a state colorless to the naked eye. It is washed with water and counterstained with a pink or brown dye. Upon examination under a microscope the bacterial cells will appear either violet due to the first stain or pink or brown with the counterstain. The difference in this staining behavior in different types of bacteria is due to the peculiar composition of the protoplasm of the cell and its interaction with the reagents employed. Bacteria of a protoplasmic type which retain the violet stain are said to be Gram-positive and those which do not hold it but instead take up the pink or brown counter stain are called Gram-negative. In subsequent discussion of antibiotics there is a sharp distinction in their reactions to these substances by gram-positive and gram-negative bacteria. Some antibiotics are antagonistic to only one of the two groups of bacteria and some can inhibit both sorts.

THE NATURE OF ANTIBIOTICS

The various chemical compounds called antibiotics have certain properties which differentiate them from common antiseptics and disinfectants. In the first place, they are produced by living organisms, although recently penicillin has been synthesized directly from non-living chemicals. Antibiotics in general may have merely an inhibitory effect on the growth of bacteria or they may actually destroy them by a complete dissolution called lysis. Waksman classifies antibiotics in the broad sense as any substance which may produce the two effects above mentioned on bacteria. These antibiotics may be products of higher plants, like quinine from the Chinchona tree, certain proteins of wheat flour, the oils in onions and garlic which kill not only bacteria but as Professor B. P. Tokin (9) of Russia showed in 1944 may kill higher organisms like yeasts. He calls these antibiotics *phytoncides.* Likewise in 1944 Cavallito (10) and Baily of Rensselaer, New York, showed that the juices of burdock, butter-cup, dog-tooth violet and wild ginger, all contained similar antibiotic substances. These men showed also that the amino acid, cystine, inactivated these phytoncides and also the antibiotics derived from the lower organisms such as molds, like penicillin and streptomycin. In January, 1947, Dr. Alfred Marshak of the U. S. Public Health Service, reported an antibiotic for the tuberculosis organism derived from an epiphytic lichen which grows in California, *Ramalina reticulata,* called Spanish Moss. Its yellow crystals retard tuberculosis in experimental animals and appears to be non-toxic. Waksman includes in the broad sense antibiotics derived from animals such as lactenin and lysozyme found in tears and perspiration. But more specifically the therapeutic antibiotics refer to the antagonistic substances produced by micro-organisms. In 1903 Krenckner

(11) noticed that the culture filtrates of bacteria inhibited the growth of bacteria. It is now known that certain bacteria, fungi and actinomyces do produce these substances. These antibiotics are very selective in their action. They affect chiefly the gram-positive bacteria and to a lesser extent the gram-negative bacteria and a few antibiotics can inhibit the growth of both types of bacteria—each antibiotic thus has its own bacteriostatic spectrum. Their production is determined by the strain of the organism, the composition of the culture medium, the temperature of incubation, the age of the culture and the aeration. The antibiotics vary greatly in their action on bacteria, their toxicity to the animal in which the bacteria live and in their practical uses in treating disease. Thirty-seven or more of these antibiotics have been isolated and studied for their chemical properties and their biological activities. A few of the commoner ones are discussed here. *Actinomycetin* from *Streptomyces albus* is soluble in water but precipitated by alcohol, is thermolabile and protein in nature; it is lytic to dead gram-negative bacteria and to some living gram-positive forms. On the other hand, *actinomycin* is secured from *Streptomyces antibioticus*. It is soluble in ether and alcohol, insoluble in petrol ether; orange colored; thermolabile and is lytic for gram-positive bacteria and in higher concentration for gram-negative bacteria and is highly toxic to animals. Here then are two antibiotics from closely related soil organisms but with quite different properties. *Aspergillic acid* is derived from *Aspergillus flavus*, a fairly common mold. It is soluble in water, alcohol, ether and acetone but insoluble in petrol ether. It is acid in nature and is lytic to both gram-positive and gram-negative bacteria. Another antibiotic is *clavicin*, *clavitin* or *patulin* which is formed in several species each of the molds *Aspergillus* and *Penicillium*. It is soluble in ether, chloroform, alcohol and water. It is lytic to both gram-positive

FIG. 3. Sir Alexander Fleming.

and gram-negative bacteria as well as fungi. It is highly bactericidal but is toxic to animals. *Flavicin, flavitin, aspergillin* or *parasitin* is a substance produced by three different species of the mold *Aspergillus* and in all its characteristics is similar to the antibioltic *penicillin. Gramicidin* is an antibiotic isolated from *Bacillus brevis.* It is a polypeptide and is thermolabile; soluble in ether and alcohol; lytic to gram-positive bacteria but is hemolytic in the bodies of animals. The common mold *Penicillium,* in at least four or five species, produces several antibiotics. The most famous is *penicillin.* Others are *penicillic acid. penicidin, notatin* and *mycoin. Penicillin* is isolated from *Penicillium notatum;* soluble in alcohol and water and in ether at pH 2; thermolabile and lytic to gram-positive aerobic and anaerobic bacteria and of low toxicity in animals. Still other antibiotics are *streptomycin* and *streptothricin,* both derived from two different species of *Streptomyces,* an Actinomycete genus. They are both soluble in water and in acid alcohol, insoluble in ether. They behave like organic bases and are thermostable. *Streptomycin* is lytic to gram-negative bacteria and of low toxicity in the bodies of animals. *Streptothricin* is lytic to gram-negative and some gram-positive bacteria and has a higher toxicity in animals. *Bacitracin* (12) is another new antibiotic isolated from strains of *Bacillus subtilis.* It is water soluble, thermostable and acid stable, non-hemolytic, non-stable in alkali, resists digestion by pepsin and trypsin and is non-toxic in animals. *Subtilin,* also derived from *Bacillus subtilis,* is soluble in alcohol and is stable to heat and acid but unstable in alkali. It is lytic to both gram-positive and gram-negative bacteria and slightly toxic to animals. *Chlorellin* (13) is an antibiotic derived from a green alga, *Chlorella vulgaris.* It is antagonistic to the same groups of organisms that are susceptible to penicillin but has the added advantage that the alga is much simpler to cultivate than fungi, needing only water, a few mineral salts and an adequate amount of carbon dioxide blown through the culture. Of all the thirty-seven or more antibiotics discovered, only *penicillin* and *streptomycin* have come into wide general use and to a lesser extent *bacitracin* and *chlorellin.*

We will now discuss the discovery and manufacture of these two new and dramatic drugs.

First I should like to relate an example of natural antibiosis that occurred in my own observation. About four years ago in Toledo a friend of mine was troubled with an infection of "athlete's foot" fungus on his leg. He consulted a dermatologist who treated it with drugs and X-ray therapy but the infection was slow to heal. After several months, my friend had the misfortune to break his leg in a traffic accident and was hospitalized. While in the hospital he contracted erysipelas severely on his back and legs. This was treated by routine methods and in a short time was cured but the "athlete's foot" fungus which had been living in the area of skin attacked by the erysipelas had also entirely disappeared. This was a natural case of antibiosis in which the *Streptococcus* organism of erysipelas had destroyed the fungus *Trichopyton* which caused the "athlete's foot" disease.

The discovery of penicillin occurred in 1929 by Dr. Alexander Fleming, now Sir Alexander Fleming, while working at St. Mary's Hospital in London with some culture plates of *Staphylococcus aureus.* He noticed that in a plate which had become contaminated by a mold spore, the area around the mold mycelium showed a clear zone where the *Staphylococcus* had disappeared. He cultured some of this mold in broth to see if it had really killed the bacteria. In later experiments he found that if he took a drop of the broth in which the mold, identified as *Penicillium notatum,* had grown and placed it on a living culture of *Staphylococcus,* as the broth spread over and through the agar on the plate, it would kill off the bacteria. Dr. Fleming discovered that several varieties of *Staphylococcus* were susceptible to the substance in the broth and still later he learned that the bacteria causing boils, diphtheria and abscesses with pus formation could be entirely inhibited by the broth in which the mold *Penicillium* had grown. On the other hand, he learned that the colon bacillus from the normal intestine and organisms which cause typhoid, dysentery and influenza were not affected at all by the broth substance.

Next he injected the broth into animals and found that they were no more irritated than if pure sterile broth had been used In the British Journal of Experimental Pathology (14) in 1929 he modestly suggested that perhaps this antibacterial substance in the broth might be used clinically to help infections caused by the bacteria which he found susceptible to it. Since the mold which produced the antibiotic was *Penicillium*, he called the substance *penicillin*. For ten years this antibiotic excited little interest in the world: First, because it was a very unstable substance and second, it could be produced only in very small amounts. During these ten years Dr. Fleming wrote several articles in which he used penicillin to differentiate various strains of bacteria. In 1931 Clutterbuck (15) and others told in the British Biochemical Journal that they were successful in growing the mold in larger amounts and had worked out the features of penicillin chemically. In 1943, Dr. H. W. Florey (16) and others in the "Lancet" described the use of penicillin as very effective in checking infections and that it had a low toxicity in the human body.

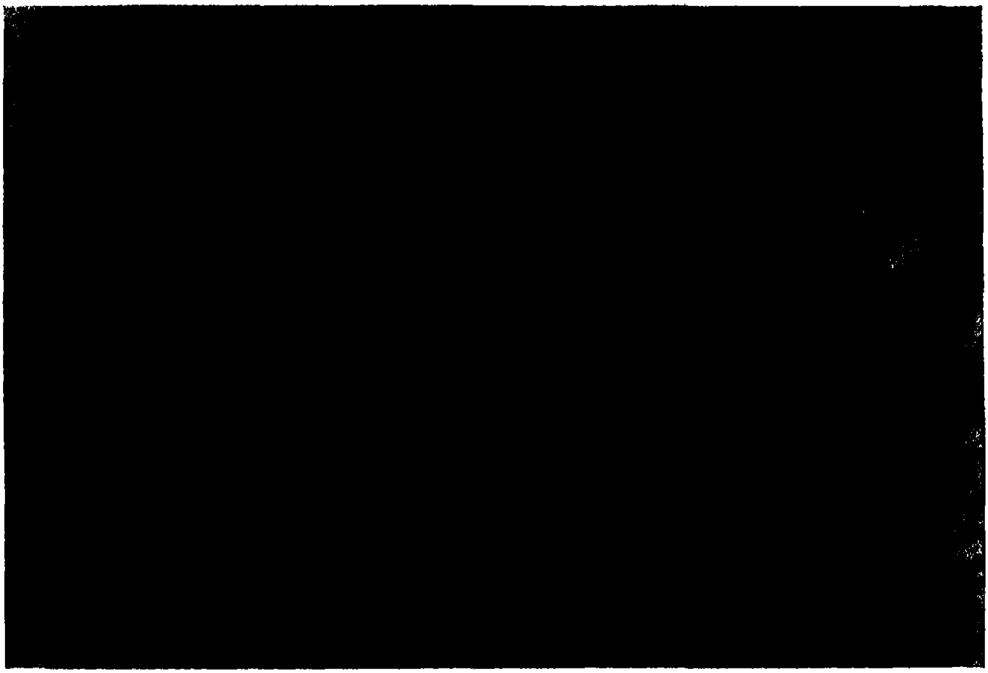

FIG. 4. Penicillin crystals. (X 500.)

Just prior to this, in 1939, Dr. R. J. Dubos (17) in the Journal of Experimental Medicine announced the isolation of some bacteriocidal fractions from the culture media in which had been grown the soil organism *Bacillus brevis*. These substances were classified as polypeptides and were named *gramicidin* and *tyrocidin*. They were clear colorless crystals and were antagonistic to a number of bacteria but clinically they were not useful on account of the relatively high toxicity to the patient.

In 1940 and 1941 Florey and his co-workers reported in some 300 papers their results in treating several hundred patients in England with penicillin. In 1941 the interest in the drug became general and Professor Florey was invited to this country by the Rockefeller Institute to attempt a large-scale production of penicillin which was then impossible in England due to the bombing and devastation of the war. Our National Research Council and the Northern Regional Laboratory of the U. S. Department of Agriculture at Peoria, Illinois, and several large pharmaceutical firms all co-operated to make large-scale production possible.

At first the yield of penicillin was only two units per milliliter of culture medium. This was not fast enough since a million units are necessary to treat a deep seated infection. The next important step was the discovery by Dr. Andrew Moyer at the Northern Regional Laboratory that a by-product of the corn refining industry, called corn-steep water could be used as an ingredient in the culture medium in which to grow the mold. When this was added, it increased the yield of penicillin to more than forty units per milliliter of fluid.

All penicillin is now produced from a highly selected strain of ***Penicillium notatum***. This mold grows most anywhere on decaying vegetables, dairy products or in the soil but a strain in a special collection called the Type Culture Collection in Washington, D. C., is labeled N. R. R. L. 832. This was found growing on a piece of decaying cantalope. This strain is the best known producer of penicillin. Penicillin made from unknown or wild strains of ***Penicillium*** have been found to induce severe anaphylactic symptoms and allergy in patients with high fever. Commercial penicillin is now carefully treated to eliminate any such dangerous proteins.

In the manufacture of penicillin the chief difficulty is to insure sterility of the cultures. It is a strange thing that this antibiotic which is a potent killer of numerous bacteria is itself killed by some of the bacteria which it cannot conquer. Therefore, it must be cultured under the most rigid aseptic conditions. The ordinary colon bacillus which is not inhibited by penicillin produces such a potent enzyme for the destruction of penicillin that it is called penicillinase by Abraham and Chain (18).

The optimum temperature for the growth of ***Penicillium*** is 24° C. The source of the carbon for its nutrition is lactose and the source of its nitrogen is sodium nitrate. Zinc ions seem also to be necessary for its production. The composition of corn-steep water which so greatly increases the yield of penicillin is not entirely known but in a recent article by Gregory Schwartzman in *Science* he showed that if cellophane is suspended in the culture medium, it also increases the yield of penicillin. It may be then that corn-steep water, a by-product in making glucose and corn-starch may contain a cellulose derivative similar to cellophane.

Since the ***Penicillium*** mold is an aerobe, it must have an adequate supply of oxygen. The aeration of the culture then had to be solved. Three devices were used to secure aeration. One was the surface method. This older method was to grow the mold in flat half-gallon bottles or flasks. The films of mold were floating in culture medium not more than 2 cm. deep. Aeration was thus by simple diffusion. In this method contamination of the bottles with foreign organisms was a great danger. A second method was the bran method. In this method coarse bran was spread in large trays and the mold culture was sprayed on the bran and after the usual growth period the penicillin was extracted from the mass. The third method is the Submerged Culture Method and all the large plants now use this procedure. The mold is grown in high cylindrical tanks each holding 1,000 gallons. Aeration is brought about by a vigorous bubbling of sterile air through the mass in the culture tanks. The yield per milliliter by this method is slightly less than culture in bottles. The only problem in the Submerged Method is to insure the complete sterilization of the large volumes of air needed to be blown through the tanks. By 1945 the combined output of twenty-one companies making penicillin was 200 billion units per month or about nine pounds of penicillin per day.

The method of extracting the penicillin from the culture medium is as follows: The pH of the fluid is adjusted to 1.9 or 2 with phosphoric acid. It is then agitated with a solvent that is immiscible with water, such as amyl acetate or chloroform. After separation of this solvent the aqueous part is discarded. The amyl acetate containing the penicillin in acid form is shaken up with a little water containing sodium bicarbonate. This converts the penicillin to the sodium salt. The sodium salt of penicillin is further purified by adsorption on columns of alumina or with activated charcoal. It is now chemically usable but it is considered desirable to remove traces of amyl nitrate that might be left, so the sodium salt is usually filtered through Seitz bacterial filters and dried by sublimation from a frozen state under reduced pressure. The product is a yellow powder which is quite stable when perfectly dry and is best kept in a refrigerator. When needed for use it is merely dissolved in water or in a normal saline solution.

ASSAY METHODS FOR PENICILLIN

The strength or concentration of penicillin is measured by a bioassay method which depends on its antibiotic properties. The unit was devised by Professor H. W. Florey and M. A. Jennings (19) and is called the Oxford unit. It was published in 1942 in the British Journal of Experimental Pathology. The Oxford unit is now the standard for this drug. It is the amount of penicillin dissolved in 50 ml. of meat extract broth which will just inhibit the growth of a test strain of *Staphylococcus aureus*. Thus a preparation of penicillin which will just inhibit the test strain of the coccus contains one unit. With a dilution of 1 : 50,000 the technic of making the assay is by the cup method. The standard coccus No. 209 is grown on a petri dish and in it are set five small porcelain cups. In two of these cups is placed a standardized solution of penicillin of one unit strength per milliliter. Into the other three cups is placed some of the penicillin solution whose assay is being made. The plates are incubated over night. In the morning the examination of the clear zones around each cup where the penicillin has penetrated the agar and killed the coccus is made. Comparisons of the widths of the zones of the known strength with those of the unknown is the basis of the assay. Pure crystallin penicillin has a standard assigned strength of 1650 units per milliliter or stated in another way 0.6 grams of penicillin has an antibiotic activity of one million Oxford units. The uses for which penicillin is indicated will be given later.

The story of the other important antibiotic, *streptomycin*, began with the search for some antagonist to the gram-negative bacteria. Penicillin combats effectively against the gram-positive forms. But against the gram-negative pathogens of typhoid, colon bacillus infections, dysentery, undulant fever and tularemia and the acid fast bacteria such as *Mycobacterium* which causes tuberculosis, it is impotent. In 1939 the Department of Microbiology at Rutgers University began to study antibioltic substances and under the leadership of Dr. Selman A. Waksman (20) they isolated seven compounds. These are: 1, *actinomycin*, which was found to be highly toxic to animals; 2, *clavicin*, which was active against gram-negative bacteria but also toxic; 3, *fumigacin*, not so toxic but also not very active; 4, *chaetomin*, which was non-toxic but also ineffective in animals; 5, *micromonosporin*, which held little promise; 6, *streptothricin*, which was effective as an antibiotic but still toxic to animals; and finally 7, *streptomycin*. This last substance was isolated from an actinomycete. These are microbial organisms between bacteria and fungi which form thread-like growths in the soil. The organism is named *Streptomyces griseus* and was isolated twenty-eight years previously, (21) as an organism living in soils and composts. In 1939 Dr. Waksman and his colleagues secured two cultures of this actinomycete. One from a heavily manured field near Rutgers and the other from the throat of a chicken. The *Streptomyces* was grown on a liquid medium which, to produce the best results, contained the elements of meat extract. The carbon nutrients could be supplied by starch and glycerol and the nitrogen from casein and sodium nitrate. The final culture medium adopted was composed of glucose, peptone, meat extract, sodium chloride and water with a pH of 6.5–7. If a culture is shaken, the growth is more rapid, a maximum growth being attained in two to three days. In stationary cultures the maximum growth requires nine days. In either method the culture medium becomes alkaline. The strains of *Streptomyces* are not quite constant but in general they undergo very little variation under cultural conditions. For the most part highly potent strains retain their potency and poor strains remain weak producers of streptomycin. The streptomycin is formed equally well in stationary or submerged cultures. Streptomycin is water soluble and may be easily isolated from the culture medium.

When the broth culture has attained its maximum antibiotic activity, the incubation is terminated and the mass is centrifuged or filtered to separate the broth. The selection of the filter is important since streptomycin is rapidly adsorbed on various filters. The filtered fluid is alkaline and is next treated with activated charcoal which completely adsorbs the streptomycin. The charcoal adsorbate is centrifuged or filtered off and washed with alcohol to remove impurities. Then it is treated with dilute acid aclohol to bring the streptomycin into solution. The acid alcohol solution is then neutralized and filtered to remove any final impurities that have precipitated out. The resulting solution is concentrated by adding ten volumes of ether which takes up the alcohol and leaves the streptomycin as a yellow, brownish or reddish aqueous concentrate. By precipitation with acetone or by dessication in a vacuum, solid streptomycin is obtained. A more pure form can be obtained by the addition of methyl orange, which is the sodium salt of helianthine. The resultant crystals are streptomycin-helianthate from which soluble salts of streptomycin can be obtained. Another method of obtaining purer salts is by precipitation of the charcoal adsorbate with phosphotungstic acid and picric acid. Reinecke salt is added to the aqueous solution which forms crystalline precipitates and by fractional distillation pure streptomycin reineckate is obtained. These are then converted to either the hydrochloride or the sulfate of streptomycin.

STREPTOMYCIN ASSAY AND UNIT STRENGTH

The assay of streptomycin may be done in various ways as the agar dilution streak, or the agar cup method or the turbidimetric method. The original unit was determined by the amount of streptomycin in one milliliter of nutrient broth which will just inhibit a given strain of *Escherichia coli*. This was called the S unit. Since this unit is so small, it was found to be more convenient to use the antibiotic in one *liter* of broth instead of a milliliter, hence this unit is called the L unit. In dealing with the pure crystalline material it was found that 1,000 L units or 1,000,000 S units could be approximated closely by dry weight, so now the G unit is used which is one microgram of dry crystalline streptomycin. In a comparison of the Oxford units of penicillin and the G units of streptomycin it must be remembered that they have no similar basis. In dry weights of the two antibiotics one streptomycin unit is one microgram whereas an Oxford unit of penicillin weighs only 0.6 microgram. The bacteria used in the two assays are also quite different, *Staphylococcus aureus* being gram-positive and *Escherichia coli* being gram-negative.

In contrast to penicillin, streptomycin is remarkably stable both chemically and biologically. The latter can be stored in a refrigerator for six months without any loss of potency; also no other organisms destroy it as they do penicillin.

Bacitracin, which was discovered in 1945 by Drs. B. A. Johnson, Herbert Anker, and Frank L. Meleney at Columbia University's College of Physicians, appeared in the broth on which was cultured organisms derived from wounds.

It is formed by a type of *Bacillus subtilis*. The filtrate is extracted with butanol, concentrated by steam distillation and precipitated as a grayish white powder. It is neutral, and unlike gramicidin or subtilin, cannot be extracted with ether, chloroform or acetone. It is water soluble and non-toxic. It is active in animals and human infections against gram-positive organisms as *Streptococcus*, *Stephylococcus* and gas-gangrene due to *Clostridium*. It is used clinically by its discoverers but is not yet standardized nor commercially available.

CLINICAL USES FOR PENICILLIN AND STREPTOMYCIN

During the latter part of the recent war Dr. Chester B. Keffer, Chairman of the Committee on Chemotherapeutic and Other Agents, of the National Research Council published a report on analyses of thousands of cases treated with penicillin. This report was issued by the Office of Civilian Distribution of Penicillin.

In the discussion of the uses for penicillin as a drug the application was divided into four classes or groups:

Group I shows that penicillin is indicated for all infections due to *Staphylococcus*, as carbuncles, meningitis, sinusitis, pneumonia, wound infections and osteomyelitis; also gas gangrene due to *Clostridia;* all infections due to *Streptococcus*, such as cellulitis, mastoiditis, meningitis, peritonitis or pneumonia; all anaerobic *Streptococcus* infections as puerperal sepsis; all infections due to ***Pneumococcus*** in the pleura, meninges or endocardium; and all cases of sulfa-resistant *Pneumococci;* and finally all infections due to gonococci.

Group II shows that penicillin is effective but its potency is not yet clearly established in cases of syphilis, actinomycosis and bacterial endocarditis.

Group III shows that penicillin is of questionable value in mixed infections in which gram-negative organisms predominate, such as ruptured appendix, liver abscesses, urinary tract infections and Rat-bite fever due to *Streptobacillus moniliformis*.

Group IV shows that penicillin is contra-indicated because it is ineffective in all gram-negative bacillary infections of typhoid, colon bacillus, dysentery, influenza, undulant fever and tularemia. Also it is impotent in tuberculosis, acute rheumatic fever, lupus, infectious mononucleosis, pemphigus, Hodgkin's Disease, acute and chronic leukemia, ulcerative colitis, coccidiomycosis, poliomyelitis, all virus diseases and cancer.

This rather complete survey indicates the clear cut benefits of its use as well as the large area of diseases in which it is of no value at all.

Now to consider the indications for streptomycin therapy. No complete summary has yet been issued for the uses of this drug since much work is still being done upon it. In general it can be stated with reasonable assurance that streptomycin is indicated in most cases of infection that are resistant or wholly untouched by penicillin, sulfa drugs or serum therapy. According to Greey (22) of Toronto University, streptomycin is effective in chronic infections of the urinary tract due to *Escherichia coli*, *Aerobacter aerogenes* or *Pseudomonas aeruginosa.* In four to eight hours after treatment with streptomycin given intromuscularly the urine was negative for these organisms. It is also indicated for infections of the intestine due to typhoid and related organisms, via., *Eberthella*, *Salmonella* and possibly *Shigella* of the dysentery organisms. Flippin (23) of the University of Pennsylvania states that patients with twenty-three million *Salmonella* (paratyphoid) bacterial count in the stools gave negative stools after four days therapy with one gram of streptomycin given orally per day.

This drug is also indicated in systemic diseases due to *Brucella* infections such as brucellosis or undulant fever. This was recently communicated by H. A. Reimann (24).

Infections due to *Klebsiella* or Friedländer's bacillus causing forms of pneumonia and a venereal disease are definitely cured by streptomycin. A report by Heilman (25) of the Mayo Clinic last year states that patients with *Klebsiella* infections of the respiratory tract showed negative sputa in a short time.

Infections due to *Pasteurella tularensis*, the organism of Rabbit Fever or tularemia, have been treated by Foshay (26) of Cincinnati University. He reports that a patient who on the eighth day after the onset of the disease received streptomycin therapy was sent home cured on the seventeenth day after admission to the hospital, although the average duration of tularemia is three to nine months.

Perhaps the most striking application of the use of streptomycin, although still in the experimental stage, is the treatment of tuberculosis. Each day at present new reports are coming out of the trials of this drug against *Mycobacterium tuberculosis*. Feldman and Hinshaw (27) of the Mayo Clinic have treated twenty-two tuberculosis patients with streptomycin for nine months. They report that it has a suppressive effect on the disease and that its progress is temporarily inhibited. It is to be hoped that research on the use of streptomycin in combating this great white plague of civilization will continue and that it will prove to be a trustworthy chemical weapon against this disease. Only last week (April 6, 1947) U. S. Surgeon General Thomas Parran appeared before the Senate Appropriations Committee and urged that it approve a fund of one million dollars for streptomycin research against tuberculosis. Dr. Herman E. Hilleboe, in charge of the research, told a committee in the Senate that while the original cost of streptomycin of twenty dollars per gram is now reduced to three dollars per gram, even yet at the present rate it requires ten to twelve dollars' worth of the drug daily for each patient.

CLINICAL ADMINISTRATION OF ANTIBIOTICS

Penicillin may be administered intramuscularly, intravenously or into body cavities such as the pleura and the sub-arachnoid space, or locally. Some of its salts are irritating to tissues, notably the sodium salt. A constant intravenous drip injection of thirty to forty drops per minute into a vein has been found most effective in reducing acute infections. It is excreted very rapidly in the urine and two hours after an initial dose is given, it is impossible to detect it in the blood. About 40,000 to 120,000 units per day bring susceptible infections rapidly under control.

Streptomycin also may be given by intravenous or intramuscular injection. It likewise is rapidly excreted by the kidneys but by frequent injections a constant therapeutic level may readily be maintained in the blood. By oral administration streptomycin does not easily get into the blood stream and so its effectiveness is not gained by administrations through the mouth. But in the intestine it is not destroyed and its presence can easily be detected in the stools where it exerts a markedly repressive effect on the normal bacterial population of the intestine. Streptomycin given by injection may be quite painful and one symptom of its use over a period is the production of tinnitus or a ringing sensation in the ears. In some cases this is extended to deafness for a longer or shorter time following its employment.

In concluding this discussion of antibiosis I am sure that we all agree that the present decade which has made possible the applications of these miracle-working antibiotic substances has placed in the hands of man one of the most powerful weapons against disease and that the life and health of millions will be preserved by the patient studies of men like Fleming and Waksman. They will be rated in history with the great benefactors of our race.

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A NEW SYNTHETIC RUBBER

A new synthetic rubber, recently revealed by William O'Neil, president of The General Tire & Rubber Company, was one of the main topics for discussion at a recent company research panel headed by Gil Swart, General's chief research chemist.

The research experts, including professors from colleges with which General has a research arrangement and representatives from many General Tire plants, outlined plans for the new rubber that comes closer to matching all the advantages of natural rubber than anything now available. It has chlorinated styrene as its basic ingredient. News of the proposed uses for this rubber will be released soon.

A LIST OF BOOKS ON THE PERSONALITIES OF GEOLOGY

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INTRODUCTION

Geological textbooks, memoirs, monographs, and reports properly deal with the facts, principles, deductions and applications of the science of the earth. Here and there the reader or student catches glimpses of the men who gathered the facts, made the deductions, and originated the philosophical principles; or finds fragments of the history of the development of geology. But aside from this vast storehouse of scientific information, there is a small but precious number of books recording the lives of geologists, their letters, travels, and history of their building our knowledge of the earth and its past.

The writer has not seen any lists[1] of this aspect of geology,—its "human side," to overwork a tired phrase, and presents below a list of those which have come under his notice, with some annotations which may be of use to those who wish to read something about their predecessors, how they worked, their troubles and triumphs, their friends and adversaries. What geologist or enthusiast will not feel a glow of pleasure after having been, vicariously—

With the versatile Scottish editor, Hugh Miller, on the Island of Hoy, Orkney, as, wrapped in his plaid, he carved his initials of the Dwarfie Stone, under which he had sought shelter from the boreal rain; or with him and his friend the Parson of the Small Isles, as they cruised the waters of the Hebrides in the church yacht "Betsey"; or with him as he tramped the shores of Cromarty and discovered the weird fish of the Old Red Sandstone?

With the young and uncertain Charles Darwin, bitterly seasick as the "Beagle" battled her way through the Straits of Magellan towards the South Seas where first germinated in his mind the seed of evolutionary theory; or with him in Chile as he sees a rare fox intently watching officers working a theodolite and by quietly walking up behind, kills it with a blow of his geological hammer?

With the brilliant but hasty William Buckland as he crawled into Kirkdale Cavern in 1821 to discover a veritable boneyard of ancient mammal bones; or with him as he announces to his class at Oxford: "The next lecture will take place in the fields above the quarry at Stonesfield"?

With the eager young clergyman Adam Sedgwick, knowing little or nothing of geology, as he accepts the Woodwardian Professorship at Cambridge; or with him soon after as he struggles to unravel the Cambrian succession in North Wales?

With lofty-seeming but excitable Charles Lyell as he jolted and bounced by stage-coach from Cincinnati to Cleveland in 1842; or with him on his first trip to Switzerland as he walked from Chamonix over the Mer de Glace and other glaciers to Le Jardin and back—48 miles—"too much for one day"; or with him when he hired a smith to carve his initials and date on the rocks at water level on the Swedish coast so that later geologists might measure the rate of uplift; or with him again, now a baronet and the leading geologist of Britain, as he visits his queen at Osborne and expounds the Darwinian theory?

With the choleric titan of Albany, James Hall, as he took passage on the night steamer to New York and quietly threw overboard the entire edition of a geological chart on which his name failed to appear; or with him in horse and buggy, jogging over the roads of the Finger Lake region of New York, unravelling the stratigraphy of the Devonian rocks and turning out their treasure-trove of fossils from which he wrested international fame?

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[1] There are many biographical references, especially to periodicals, in Merrill's *Contributions to the History of American Geology*, Appendix B, pp. 689–715.

With the young red-bearded giant, Raphael Pumpelly, as he posted across Siberia in the dead of winter, squeezed with another passenger, a handsome and mysterious young woman, in a sledge drawn by relays of galloping ponies?

With bold and ambitious Major Powell as he launched his boats on the Colorado River at Green River City for the first trip down the Grand Canyon,—a trip from which no one expected his return?

With the wealthy bachelor, Othniel Charles Marsh of Yale and his group of adventurous students as they braved the very real dangers of the West in 1870 to plunder the vast Tertiary mammal deposits; or with him as he awaited a reply to a cablegram sent to Professor Geinitz in an effort to buy the second specimen of *Archeopteryx?*

Or with zealous Amos Eaton in 1826 as he took a party of students on a geological tour by canal boat ("The School Flotilla") on the new Erie Canal,—one of the first summer field courses?

ANNOTATED LIST

In the list below, divided into five groups: *biographies*, *journals* and *diaries*, *travels*, *histories of geology*, and *miscellaneous*, the arrangement is alphabetical by authors except for the biographies which are listed according to the name of the subject of the book. With one or two exceptions, the list includes only those which have appeared as *books*, and thus deliberately excludes the numerous short biographical notices and memoirs, and sketches which have appeared in various journals. It is certainly incomplete, and the writer will welcome additions and corrections.[2]

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Son of Louis Agassiz, an accomplished zoologist, oceanographer and geologist, who made a fortune in Keweenaw copper and expended much of it on the Museum of Comparative Zoology and long geological and biological expeditions in the Pacific.

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[2] Many important additions to the writer's original list were made by Dr. George W. White, of the University of Illinois; for which, sincere thanks are here given.

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Appealing and sympathetic account of the keen naturalist, discoverer of many new plants and fossil fishes, baker by trade, friend of Hugh Miller, Peach, and Geikie, but unknown to most of his contemporaries.

Eaton, A. McAllister, E. M. *Amos Eaton, Scientist and Educator,* 1776–1842. Univ. Pennsylvania Press, 1941.

Remarkably thorough study of one of the pioneer teachers of science in America, builder of Renssalaer Polytechnic Institute.

Forbes, J. D. Shairp, Tait & Adams-Reilly. *Life and Letters of James David Forbes, F.R.S.* Macmillan, 1873.

Forbes, professor of natural philosophy at Edinburgh, later at St. Andrews, is famous for his studies of glaciers.

Forbes, E. Wilson, G., & A. Geikie. *Memoir of Edward Forbes.* 1860.

Edward Forbes was a pioneer in the study of animal ecology and geography.

Geikie, A. Geikie, A. *A Long Life's Work, an Autobiography.* Macmillan, London, 1924.

Geikie was an outstanding figure in British geology, long director of the Geological Survey of Great Britain.

Geikie, J. Newbiggin, M. I., and J. S. Flett. *James Geikie, the man and the geologist.* Edinburgh & London, 1917.

Hall, J. Clarke, J. M. *James Hall of Albany, Geologist and Paleontologist,* 1811–1898. Albany, 1921.

One of the best biographies of a scientist. Excellent study of the great Paleozoic paleontologist and lively account of the early days of geologic study of the classic ground in New York and adjoining areas. Much material on contemporary associates and geological activities.

Horner, L. Lyell, K. M. *Leonard Horner.* 2 vols., London, 1890.

Horner was a Scottish geologist and merchant, the father-in-law of Charles Lyell.

Houghton, D. Bradish, A. *Memoir of Douglas Houghton.* Detroit, 1889.

Includes reprints of early geological writings of Houghton, pioneer Michigan geologist.

Hubbard, B. Hubbard, B. *Memorials of a Half-Century in Michigan and the Lake Region,* 1814–1896. Putnam's, N. Y., 1888.

Huxley, T. H. Huxley, L. *Life and Letters of Thomas Henry Huxley.* 2 vols., Appleton, 1901.

Huxley, celebrated biologist and forensic scientist, was the friend of Darwin and champion of the theory of evolution.

King, C. *Clarence King Memoirs (The Helmet of Mambrino).* Putnam, 1904. (Publ. for King Memorial Comm. of Century Ass'n.).

Kornitzer, L. Kornitzer, L. *Gem Trader.* Sheridan House, 1939.

The commerce of gem-stones, by an old and skilled dealer.

(French Savants). Lacroix, A. *Figures de Savants.* 2 vols., Paris, 1932.

Short studies of the lives and work of 31 French mineralogists and geologists, from Desmarest to Haug, with portraits and facsimiles of handwriting. Important source of information on French scientists.

Lamarck, J. B. P. Roule, L. *Lamarck et l'Interprelation de la Nature.* Paris, 1927.

Lamarck was the famous zoologist and paleontologist, proposer of an important pre-Darwinian evolutionary hypothesis.

Packard, A. S. *Lamarck, the Founder of Evolution, his Life and Work, with Translation of his writings on organic Evolution.* Longmans, Green, N. Y., 1901.

LeConte, J. (Armes, W. D., ed.) *Autobiography of Joseph LeConte.* Appleton, 1903.

Very readable reminiscences of the student of Louis Agassiz and early professor of geology at the University of California.

Lesley, J. P. Ames, M. L. *Peter and Susan Lesley.* 2 vols., Knickerbocker Press, N. Y., 1909.

Linnaeus, C. Hagberg, K. *Carl Linné, "Le Roi des Fleurs."* (transl. from Swedish by Hammar and Metzger.) Paris, 1944.

Logan, W. E. Harrington, B. J. *Life of Sir William E. Logan.* London, 1883.

Good biography of a pioneer in Canadian geology.

Lyell, C. (Lyell, Mrs., ed.) *Life, Letters, and Journals of Sir Charles Lyell, Bart.* 2 vols., Murray, London, 1881.

Thoroughly readable selections from the letters and journals of the celebrated British geologist, scientific descendant of Hutton and expounder of uniformitarianism.

Bonney, T. G. *Charles Lyell and Modern Geology.* Macmillan, N. Y., 1895.

Based upon the "Life and Letters," but a more connected biography.

Mantell, G. Spokes, S. *Gideon Algernon Mantell.* London, 1927.

Marsh, O. C. Schuchert, C., & C. M. LeVene. *O. C. Marsh, Pioneer in Paleontology.* Yale Univ. Press, 1940.

An excellent companion volume to Osborn's "Cope." Marsh and Cope, the outstanding American vertebrate paleontologists, were bitter rivals.

Michell, J. Geikie, A. *Memoir of John Michell.* Cambridge Univ. Press, 1918.

Michell was "Fellow of Queen's College in Cambridge, 1749, Woodwardian Professor of Geology in the University, 1762."

Miller, H. Brown, T. N. *The Life and Times of Hugh Miller.* New York, 1859.

Poor.

Miller, H. *My Schools and Schoolmasters; or, the Story of my Education.* Boston, 1863.

The best extant account of the early life of Hugh Miller.

Bayne, P. *The Life and Letters of Hugh Miller.* 2 vols., London, 1871.

A long, prosy, dull, poorly-documented, and generally unsatisfactory biography.

Leask, W. K. *Hugh Miller.* Edinburgh & London (Famous Scots Series), 1896.

Excellent brief biography.

Mitchill, S. Hall, C. R. *A Scientist in the Early Republic, Samuel Latham Mitchill,* 1764–1831. Columbia Univ. Press, 1934.

A fair study of one of the more important early "all-round" scientists of America, friend and helper of many others.

Murchison, R. I. Geikie, A. *Life of Sir Roderick I. Murchison.* 2 vols., London, 1875.

Well-written, like all of Geikie's works. Murchison was one of the great figures of the formative years of geology and elaborator of the Silurian System.

Owen, D. D. Hendrickson, W. B. *David Dale Owen, Pioneer Geologist of the Middle West.* Indiana Historical Collections, vol. 27, 1943.

Owen was one of the most tireless and able of the early American geologists.

Owen, R. Owen, R. *The Life of Richard Owen.* 2 vols., Murray, London, 1894.

The letters and journals of the great English 19th Century anatomist and vertebrate paleontologist, celebrated for his deductions from fragmentary fossil bones.

Pengelly, W. Pengelly, H. *A Memoir of William Pengelly of Torquay, F.R.S., Geologist.* Murray, London, 1897.

Schoolmaster and keen "amateur" geologist.

Percival, J. G. Ward, J. H. *Life and Letters of James Gates Percival.* Ticknor and Fields Boston, 1866.

Poet and first state geologist of Connecticut.

Powell, J. W. (Gilbert, G. K., ed.) *John Wesley Powell; a Memorial to an American Explorer and Scholar.* Chicago, 1903.

Powell was one of the founders of the United States Geological Survey, famous for his geological explorations in the West.

Prestwich, J. Prestwich. *Life and Letters of Sir Joseph Prestwich.* London & Edinburgh, 1899.

Pumpelly, R. Pumpelly, R. *My Reminiscences.* 2 vols., Henry Holt, 1918.

One of the most readable of scientific autobiographies, well-known for its real adventure and anecdotes.

Rafinesque, C. Rafinesque, C. R. *A Life of Travels.* Chronica Botanica, vol. 8, 1944. (1st ed., Phila., 1836.)

Fascinating self-portrait of one of the eccentrics of natural history, prodigious laborer among the hosts of new animals, plants, and fossils of America.

Fitzgerald, T. *Rafinesque, a Sketch of his Life, with Bibliography.* Des Moines, 1911.

Ramsay, A. C. Geikie, A. *Memoir of Sir Andrew Crombie Ramsay.* Macmillan, 1895.

Excellent for its summaries of work of the period and portraits of geologists of the time.

Rogers, W. B. Rogers, W. B. *Life and Letters of W. B. Rogers.* 2 vols., Riverside Press, Cambridge, Mass.

Saussure. Freshfield, D. W. *The Life of Horace Benedict de Saussure.* 2 vols., London, 1920.

Say, T. Weiss, H. B., & G. M. Ziegler. *Thomas Say, early American Naturalist.* Thomas, Springfield, Ill., 1931.

Say, who thought little of anything but his invertebrates, was a wistful and gentle figure in the roaring times when the midwest was the frontier.

Scott, W. B. Scott, W. B. *Some Memories of a Paleontologist.* Princeton Univ. Press, 1939.

Highly interesting, and in places equally diverting, recollections of one of our great vertebrate paleontologists.

Sedgwick, A. Clarke, J. W., & T. McK. Hughes. *The Life and Letters of the Reverend Adam Sedgwick.* 2 vols., Cambridge Univ. Press, 1890.

Exhaustive record of one of the great figures in British geology.

Shaler, N. S. Shaler, N. S. *The Autobiography of Nathaniel Southgate·Shaler, with a supplementary Memoir by his Wife.* Houghton Mifflin, 1909.

Silliman, B. Fisher, G. P. *Life of Benjamin Silliman.* 2 vols., Scribner's, N. Y., 1866.

Life of the chemist, mineralogist, and founder of the *American Journal of Science* ("Silliman's Journal"), valuable for letters from other scientists of the early decades of the 19th Century.

Sherborn, C. D. Norman, J. R. *Squire Memories of Charles Davies Sherborn.* Harrap, London, 1944.

A fine account of one of the interesting figures at the British Museum (N. H.), famous bibliographer, indexer, and ferret of scarce scientific books.

Smith, W. Phillips, J. *Memoirs of William Smith, LL.D.* London, 1844.

Cox, L. R. *New Light on William Smith and his Work.* Proc. Yorks. Geol. Soc., vol. 25.

Sternberg, C. H. Sternberg, C. H. *The Life of a Fossil Hunter.* Henry Holt, N. Y., 1909.

Sternberg was the great professional fossil collector in the western United States.

Stow, G. B. Young, R. B. *Life of G. B. Stow.* London, 1908.

Stow was the Robert Dick of South Africa.

Werner, A. G. Frisch, S. G. *Lebensbeschreibung Abraham Gottlob Werner.* Leipzig, 1825.

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Ward, L. F. Cape, E. P. *Lester F. Ward, a personal Sketch.* Putnam's, 1922.

Completely ignores Ward's work in paleobotany, useless from a scientific standpoint, hardly readable otherwise.

Whitney, J. D. Brewster, E. T. *Life and Letters of Josiah Dwight Whitney.* Houghton Mifflin, N. Y., 1909.

Wright, G. F. Wright, G. F. *Story of my life and work.* Bibliotheca Sacra, Oberlin, Ohio, 1916

JOURNALS AND DIARIES

Barlow, N. *Charles Darwin and the Voyage of the Beagle.* Philosophical Library, N. Y., 1946

Selected series of letters, many hitherto unpublished, by Darwin, with extracts from his diary, during the voyage of the *Beagle.*

Curwen, E. C. *The Journal of Gideon Mantell, Surgeon and Geologist.* Oxford Univ. Press, 1940.

The revealing journal of the discoverer of Iguanadon, especially interesting for its candid remarks on famous geologists of the early 1800's.

Darwin, C. *Journal of Researches into the Geology and Natural History of the various Countries visited during the Voyage of H. M. S. Beagle.* First Ed., 1839 (many other editions).

One of the "musts" for every student of earth sciences.

TRAVELS

Agassiz, E. C. *A Journey to Brasil.* Boston & N. Y., 1895.

Agassiz, L. *Lake Superior: its Physical Character, Vegetation, and Animals . . . With a Narrative of the Journey by J. Elliott Cabot, and Contributions by other Scientific Gentlemen* Boston, 1850.

Agassiz's first geological work in the United States.

Ansted, D. T. *Scenery, Science and Art.* London, 1854.

". . . extracts from the note-book of a geologist and mining engineer."

Campbell, J. F. *My Circular Notes.* 2 vols., Macmillan, London, 1876.

Letters from a leisurely round-the-world jaunt, with geological and other observations, by the author of "Frost and Fire." Interesting for the author's somewhat eccentric outlook.

Collini, M. *Journal d'un Voyage, qui contient different Observations minéralogiques.* Mannheim, 1776.

Account of a trip through the Rhine Valley region searching for materials for the cabinet of the Elector of the Palatinate; interesting observations on the columnar basalts which Collini discovered in the Rhine Gorge.

De Luc, J. A. *Geological Travels.* 3 vols., London, 1810–11.

Geological Travels in some parts of France, Switzerland and Germany. 2 vols., London, 1813.

Dennison, L. *Caroni Gold.* Hastings House, 1943.

Adventures of a mining geologist in the gold-workings on the Caroni river in southeastern Venezuela.

Faujas de Saint Fond, B. *A Journey through England and Scotland to the Hebrides in* 1784 (transl. by A. Geikie). 2 vols., Glasgow, 1907.

Very readable account of a geological tour by a famous geologist of the 18th Century. Faujas was one of the first geologists to visit Fingal's Cave, Island of Staffa.

Forbes, J. D. *Travels in the Alps of Savoy and other parts of the Pennine Chain, etc.* Black, Edinburgh, 1843.

Classical reading for students of glaciation; early theory of glacial movement.

Lyell, C. *Travels in North America in the Years* 1841–42. 2 vols., New York, 1845.

Lyell came to America to give the Lowell lectures and took the opportunity to travel widely, studying not only the geology but also the manners and ways of the New World,—he found much that was good, some that was bad.

A Second Visit to the United States of North America. 2 vols., London, 1849.

Miller, H. *The Cruise of the Betsey; or, a Summer Ramble among the fossiliferous Deposits of the Hebrides.* (With: *Rambles of a Geologist; or, Ten Thousand Miles over the fossiliferous Deposits of Scotland.*) Boston, 1858.

Perhaps the most readable of Hugh Miller's works. If one does not long to visit the Hebrides and the Orkneys after reading this, he does not much love geology.

Pfitzenmayer, E. W. *Les Mammouths de Sibérie* (transl. from Russian by G. Montandon.) Payot, Paris, 1939.

Absorbing story of two expeditions to northeastern Siberia to recover frozen mammoth carcasses.

Pumpelly, R. *Across America and Asia. Notes of a five years' Journey around the World and of Residence in Arizona, Japan and China.* New York, 1870 (several eds.).

Pumpelly's famous trip around the world via an unusual route. Also re-counted in shorter form in his "Reminiscences" (see *Biographies*).

Rainier, P. *My vanished Africa.* Yale Univ. Press, 1940.

American Hazard. Murray, London, 1942.

Green Fire. Random House, N. Y., 1942.

Exciting account of a mining geologist's work re-opening some of the celebrated emerald mines of Colombia.

Schoepf, J. D. *Beyträge zur mineralogischen Kenntniss des ostlichen Theils von Nord Amerika.* Erlangen, 1787.

One of the first, if not the first, books on the geology of North America.

Travels in the Confederation (1783–84). (Transl. by A. J. Morrison.) 2 vols. Campbell, Phila., 1911.

Tavernier, J.-B. *Travels in India by Jean-Baptiste Tavernier, Baron of Aubonne.* 2 vols., Oxford Univ. Press, 1925.

Tavernier made several trips to the Orient in the 17th Century. Much valuable first-hand information on the mines of Golconda and famous precious stones now lost.

Willis, B. *Living Africa, a Geologist's Wanderings in the rift Valleys.* Whittlesey House, N. Y., 1930.

HISTORY OF GEOLOGY AND RELATED SCIENCES

Adams, F. B. *The Birth and Development of the Geological Sciences.* Baltimore, 1938.

Thoroughly documented and exhaustive, but weak in the field of paleontology.

Berkey, C. P. (ed.). *Geology*, 1888–1938. Fiftieth Anniversary Volume, Geological Society of America, 1941.

Contains useful summaries of progress in the fields of geology during the first 50 years of the Geological Society of America.

Fenton, C. L., and **M. A. Fenton.** *The Story of the great Geologists.* Doubleday Doran, 1945.

Not as broad as the title indicates. Good, brief account of the founders of geology, but concentrating almost wholly on American geologists after reaching the middle of the 19th Century.

Flett, J. S. *The first Hundred Years of the Geological Survey of Great Britain.* London, 1937.

Geikie, A. *The Founders of Geology.* Macmillan, London, 1897; 2nd ed., 1905.

The best account of the development of geology during the 18th and 19th Centuries.

Kobell, F. von. *Geschichte der Mineralogie von* 1650–1860. Munich, 1864.

Margerie, E. de. *Critique et Géologie. Contribution à l'Histoire des Sciences de la Terre.* vol. 1, Paris, 1943.

Autobiographical review of de Margerie's great contributions to geology and geography, with many portraits, illustrations and facsimiles.

Merrill, G. P. *Contributions to the History of American Geology.* U. S. Nat. Mus. Rep. (1904), 1906.

Contributions to a History of American State Geological and Natural History Surveys. U. S. Nat. Mus., Bull. 109, 1920.

The first one hundred Years of American Geology. New Haven, Yale Univ. Press, 1924.

Peattie, D. C. *Green Laurels, the Lives and Achievements of the great Naturalists.* Lit. Guild, 1936.

Mainly about the great botanists and zoologists, but important to students of paleontology.

Ramsay, A. C. *Passages in the History of Geology.* London, 1848, 1849.

Rickard, T. A. *A History of American Mining.* McGraw-Hill, N. Y., 1932 (A. I. M. E. Series).

Woodward, H. B. *History of the Geological Society of London.* London, 1907.

History of Geology. Putnam's, N. Y., 1911.

Brief but comprehensive.

Zittel, K. A. von. *Geschichte der Geologie und Paläontologie.* 1899.

History of Geology and Paleontology (transl. by M. M. Ogilvie-Gordon). London & N. Y., 1901.

Brief, but still the best over-all history of geologic science. The German edition is longer.

MISCELLANEOUS

Benfield, E. *Purbeck Shop, a stonecutter's Story of Stone.* Cambridge Univ. Press, 1940.

Well-written story of the ancient craft of winning and working Purbeck stone in England.

Barbour, T. *A Naturalist's Scrapbook.* Harvard Univ. Press, 1946.

More anecdotes, posthumously published, by the late director of the Museum of Comparative Zoology.

Digby, Bassett. *The Mammoth, and Mammoth-Hunting in North-East Siberia.* Appleton, N. Y., 1926.

Dohm, B. *Stielauge der Urkrebs, eine Kronik aus Urzeiten unserer Erde.* Leipzig, 1933, 1942.

The somewhat anachronistic but amusing life and loves of Stalkeye the Trilobite (*Cyphaspis ceratophthalmus*).

Geikie, A. *Geological Studies at Home and Abroad.* Macmillan, 1882.

Scottish reminiscences. Maclehose, Glasgow, 1904.

Lee, J. E. *Note-Book of an amateur Geologist.* Longmans, Green, 1881.

Mostly reproductions of sketches of geological structures from the notebook of a widely-travelled "amateur."

Lees, E. *Pictures of nature in the Silurian region around the Malvern hills and vale of Severn.* London & Malvern, 1856.

Miller, Hugh. *The Old Red Sandstone; or, new Walks in an old Field.* Boston, 1860 (1st ed., 1841).

One of the few literary classics of geology. Hugh Miller here first made known to the layman the ichthyological wonders of the Old Red Sandstone.

Monnickendam, A. *Secrets of the Diamond.* Frederick Muller, London, 1941.

One of the best recent books on the fascinating history of the diamond trade.

Murdoch, A. *Boom Copper.* Macmillan, N. Y., 1943.

The story of the Keweenawan copper mines.

Osborn, H. F. *Impressions of great Naturalists.* Scribners, 1924.

Sternberg, C. H. *Hunting Dinosaurs in the Bad Lands of the Red Deer River, Alberta, Canada.* San Diego, 1932.

Continuation of "Life of a Fossil-Hunter" (see *Biographies*).

Summers, R. A. *Conquerors of the River.* New York, 1939.

Semi-fictional account of Major Powell's famous expedition down the Grand Canyon of the Colorado.

Taine, J. (E. T. Bell). *Before the Dawn.* Williams & Wilkins, Baltimore, 1934.

Well-written, fictional account of a "time-reversal" machine which re-captured events of the geologic past.

Tait, S. W., Jr. *The Wildcatters.* Princeton Univ. Press, 1946.

Independent oil-hunting in America and the men who drilled wildcat wells.

Termier, P. *A la Gloire de la Terre; Souvenirs d'un Géologue.* Paris, 1924.

La Joie de connaitre; Suite de "A la Glorie de la Terre. Paris.

A NEW EYE-BANK

An affiliated "Eye-Bank" has been organized in New Orleans, La., which will have the cooperation of the Louisiana State University Medical School and the Tulane University Medical School and Hospital, it was announced recently at national headquarters of The Eye-Bank for Sight Restoration, Inc., 210 East 64th Street, New York City. Other affiliated Eye-Banks are functioning in Boston and Chicago.

The new Eye-Bank is located in the Hutchinson Memorial Building, New Orleans, and Mrs. Orville Ewing is serving as Executive Director. The officers are Charles E. Fenner, President; Dr. William B. Clark, First Vice-President; George L. Hardin, Second Vice-President; John F. Reilly, Treasurer; and John W. Sims, Secretary.

The Eye-Bank for Sight Restoration, Inc., in New York and its three affiliated Eye Banks collect and preserve healthy corneal tissue from human eyes for transplanting to blind persons who have lost their sight because of corneal defects, and this tissue is available to surgeons who are qualified to perform the corneal transplant operation. Two other objectives are the training of surgeons in the technique of the delicate corneal graft operation and the furtherance of research studies.

Dr. Clark, Vice-President of the New Orleans Eye Bank, who is a practicing ophthalmologist in that city, recently visited the national headquarters of The Eye-Bank for Sight Restoration, Inc., in New York to observe the methods used there as a model for the new affiliated Eye-Bank. Earlier, visits to New Orleans in connection with this project were made by Mrs. Aida de Acosta Breckinridge, executive director at national headquarters, and Dr. R. Townley Paton, New York ophthalmologist and Vice-President of the Eye-Bank there.

ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. XIV[1]

CLYDE H. JONES,
The Ohio State University

1. *Ophioglossum vulgatum* L. Adder-tongue. Hocking Co. Floyd Bartley. Ringgold, Morgan Co. Clyde H. Jones.

3. *Botrychium neglectum* Wood. Wood's Grape-fern. Hocking Co. Floyd Bartley.

33. *Dryopteris noveboracensis* (L.) Gr. New York Shield-fern. Dundee, Tuscarawas Co. Charles Riley.

34. *Dryopteris thelypteris* (L.) Gr. Marsh Shield-fern. Augusta Twp., Carroll Co. Forest Buchanan.

37. *Dryopteris goldiana* (Hook.) Gr. Goldie's Shield-fern. Camp Muskingum, Carroll Co. Ethel Harper. Lake Co. Fred J. Tyler.

48. *Onoclea sensibilis* L. Sensitive-fern. Dundee, Tuscarawas Co. Charles Riley.

62. *Lycopodium selago* var. *patens* (Beauv.) Desv. Fir Club-moss. Carroll Co. Harold S. Vasbinder.

63. *Lycopodium lucidulum* Michx. Shining Club-moss. Orange Twp., Carroll Co. Forest Buchanan.

66. *Lycopodium obscurum* L. Tree Club-moss. Carroll Co. Harold S. Vasbinder.

73.1. *Pinus resinosa* Ait. Red Pine. Dundee, Tuscarawas Co. Introduced. Charles Riley.

81.1. *Echinodorus cordifolius* (L.) Griseb. Upright Bur-head. Pike Co. Floyd Bartley.

121. *Sparganium eurycarpum* Engelm. Broad-fruited Bur-reed. Fox Twp., Carroll Co. Forest Buchanan.

126. *Typha angustifolia* L. Narrow-leaf Cat-tail. Camp Muskingum, Carroll Co. Fay Given. Dundee, Tuscarawas Co. Charles Riley.

132. *Arisaema triphyllum* (L.) Torr. Jack-in-the-pulpit. Carroll Co. Harold S. Vasbinder.

141. *Scirpus cyperinus* (L.) Kunth. Wool-grass. Dundee, Tuscarawas Co. Charles Riley.

172. *Cyperus speciosus* Vahl. Michaux's Cyperus. Circleville Twp., Pickaway Co. Floyd Bartley.

174. *Cyperus inflexus* Muhl. Awned Cyperus. Union Twp., Ross Co. Floyd Bartley.

182. *Rynchospora cymosa* Ell. Grass-like Beak-rush. Oak Openings, Lucas Co. Floyd Bartley.

230. *Carex cristatella* Britt. Crested Sedge. Amsterdam, Carroll Co. Forest Buchanan.

262. *Carex meadii* Dew. Mead's Sedge. Cranberry Island, Buckeye Lake, Licking Co. Floyd Bartley and Leslie Pontius.

276. *Carex granularis* Muhl. Meadow Sedge. Fox Twp., Carroll Co. Forest Buchanan.

530. *Erythronium americanum* Ker. Yellow Dog-tooth Lily. Carroll Co. Harold S. Vasbinder.

531. *Erythronium albidum* Nutt. White Dog-tooth Lily. Carroll Co. Harold S. Vasbinder.

534. *Allium tricoccum* Ait. Wild Leek. Berne Twp., Fairfield Co. Charles Goslin.

561. *Trillium sessile* L. Sessile Trillium. Carroll Co. Harold S. Vasbinder.

564. *Uvularia perfoliata* L. Perfoliate Bellflower. Kilgore, Carroll Co. Forest Buchanan.

569. *Polygonatum comutatum* (R. & S.) Dietr. Smooth Solomon's-seal. Camp Muskingum, Carroll Co. Fay Given.

571. *Vagnera racemosa* (L.) Mor. Panicled False Solomon's-seal. Lake Co. Fred J. Tyler.

574. *Unifolium canadense* (Desv.) Greene. False Lily-of-the-valley. Carroll Co. Harold S. Vasbinder.

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[1] Papers from the Department of Botany, The Ohio State University, No. 499.

584. *Smilax rotundifolia* L. Round-leaf Greenbriar. Camp Muskingum, Carroll Co. Roy McCormick and Laurabel Moony.

585. *Pontederia cordata* L. Pickerel-weed. Ashtabula Co. H. Crofoot and Fred J. Tyler.

593. *Juncus effusus* L. Common Rush. Dundee, Tuscarawas Co. Charles Riley.

606. *Juncus brachycarpus* Engelm. Short-fruited Rush. Wayne Twp., Pickaway Co. Floyd Bartley.

606.1. *Juncus polycephalus* Michx. Many-headed Rush. Oak Openings, Lucas Co. Floyd Bartley.

627. *Iris versicolor* L. Northern Blue-flag. Lake Co. Fred J. Tyler.

637. *Cypripedium parviflorum* Salisb. Yellow Lady's-slipper. Carroll Co. Harold S. Vasbinder.

645. *Lysias hookeriana* (Gr.) Rydb. Hooker's Orchis. Camp Muskingum, Carroll Co. Ethel Harper.

682. *Ranunculus micranthus* Nutt. Rock Crowfoot. Jefferson Twp., Ross Co. Floyd Bartley.

685. *Ranunculus pennsylvanicus* L.f. Bristly Buttercup. Wayne Twp., Pickaway Co. Floyd Bartley.

689. *Ranunculus septentrionalis* Poir. Swamp Buttercup. Carroll Co. Harold S. Vasbinder.

690. *Ranunculus hispidus* Mx. Hispid Buttercup. Carroll Co. Harold S. Vasbinder.

698.1. *Ficaria ficaria* (L.) Karst. Lesser Celandine. Van Wert Co. Arthur S. Brooks.

703. *Aquilegia canadensis* L. Wild Columbine. Carroll Co. Harold S. Vasbinder.

706. *Delphinium tricorne* Mx. Dwarf Larkspur. Steubenville, Jefferson Co. Forest Buchanan.

719. *Caltha palustris* L. Marsh Marigold. Carroll Co. Harold S. Vasbinder.

720. *Hydrastis canadensis* L. Golden-seal. Rushcreek Twp., Fairfield Co. C. H. Shaw and Charles R. Goslin.

724. *Syndesmon thalictroides* (L.) Hoffmg. Rue-anemone. Carroll Co. Harold S. Vasbinder

725. *Isopyrum biternatum* Raf.) T. & G. False Rue-anemone. Crawford Co. Mary Hemmerly.

734. *Berberis thunbergii* DC. Japanese Barberry. Pleasant Twp., Fairfield Co. Escaped. Charles R. Goslin.

753. *Chelidonium majus* L. Celandine. Steubenville, Jefferson Co. Forest Buchanan.

755. *Bicuculla canadensis* (Goldie) Mills. Squirrel-corn. Yokum Hollow, Jefferson Co. Forest Buchanan.

779. *Lepidium campestre* (L.) R. Br. Field Peppergrass. Carroll Co. Harold S. Vasbinder.

786. *Thlaspi arvense* L. Field Penny-cress. Rock Run, Jackson Co. Floyd Bartley and Leslie Pontius.

802. *Barbarea barbarea* (L.) MacM. Yellow Winter-cress. Camp Muskingum, Carroll Co. Fay Given.

803. *Barbarea stricta* Andrz. Erect Winter-cress. Amsterdam, Carroll Co. Forest Buchanan.

809. *Arabis glabra* (L.) Bernh. Tower Mustard. Carroll Co. Harold S. Vasbinder.

817. *Cardamine bulbosa* (Screb.) B.S.P. Bulbous Bitter-cress. Carroll Co. Harold S. Vasbinder.

818. *Cardamine rotundifolia* Mx. Round-leaf Bitter-cress. Ross Twp., Jefferson Co. Forest Buchanan.

826. *Dentaria laciniata* Muhl. Cutleaf Toothwort. Carroll Co. Harold S. Vasbinder.

848. *Geranium maculatum* L. Wild Crane's-bill. Carroll Co. Harold S. Vasbinder.

851. *Geranium dissectum* L. Cut-leaf Crane's-bill. Jackson, Jackson Co. D. H. Harshberger via Glenn W. Blaydes.

872. *Impatience biflora* Walt. Spotted Touch-me-not. Camp Muskingum, Carroll Co. Fay Given.

874. *Impatience palada* Nutt. Pale Touch-me-not. Camp Muskingum, Carroll Co. Fay Given.

892. *Croton monanthogynus* Mx. Single-fruited Croton. Beaver Pond, Adams Co. Floyd Bartley.

897. *Tithymalus obtusatus* (Pursh.) Kl. and Garcke. Bluntleaf Spurge. Athens Co. Walter P. Porter and P. S. Wamsley.

928. *Hibiscus moscheutos* L. Swamp Rose-mallow. Buckeye Lake, Fairfield Co. Charles R. Goslin.

964. *Viola eriocarpa* Schw. Smooth Yellow Violet. Berne Twp., Fairfield Co. Charles R. and J. L. Goslin.

968. *Viola conspersa* Reich. American Dog Violet. Berne Twp., Fairfield Co. Charles R. Goslin.

970. *Viola rostrata* Pursh. Long-spurred Violet. Carroll Co. Harold S. Vasbinder.

973. *Viola odorata* L. Sweet Violet. Carroll Co. Harold S. Vasbinder.

975. *Viola blanda* Willd. Sweet White Violet. Carroll Co. Harold S. Vasbinder.

978. *Viola cucullata* Ait. Marsh Blue Violet. Jefferson Co. Forest Buchanan.

987. *Viola fimbriatula* Sm. Ovate-leaved Violet. Hocking Twp., Fairfield Co. Charles R. Goslin.

1002. *Alsine pubera* (Mx.) Britt. Great Chickweed. Yokum Hollow, Jefferson Co. Forest Buchanan.

1004. *Alsine graminea* (L.) Britt. Lesser Stitchwort. Camp Muskingum, Carroll Co. Fay Given.

1026. *Silene virginica* L. Fire Pink. Ross Twp., Jefferson Co. Forest Buchanan.

1032. *Saponaria officinalis* L. Bouncing-Bet. Camp Muskingum, Carroll Co. Fay Given.

1038. *Claytonia virginica* L. Spring-beauty. Carroll Co. Harold S. Vasbinder.

1068. *Chenopodium botrys* L. Feather-geranium. Fulton Co. Floyd Bartley.

1137.1. *Potentilla intermedia* L. Downy Cinquefoil. Pickaway Co. Floyd Bartley.

1144.1. *Duchesnea indica* (Andrew.) Focke. Indian Strawberry. Fairfield Co. Robert Goslin.

1177. *Rosa carolina* L. Swamp Rose. Camp Muskingum, Carroll Co. Fay Given.

1180. *Agrimonia rostellata* Wallr. Woodland Agrimonia. Camp Muskingum, Carroll Co. Fay Given.

1200.1. *Malus baccata* (L.) Borck. Siberian Crab-apple. Lake Co. Escaped. Fred J. Tyler.

1243. *Melilotus alba* Desv. White Sweet-clover. Camp Muskingum, Carroll Co. Fay Given.

1245. *Medicago sativa* L. Alfalfa. Camp Muskingum, Carroll Co. Fay Given.

1248. *Trifolium agrarium* L. Yellow Hop Clover. Berne Twp., Fairfield Co. Charles R. Goslin.

1256. *Trifolium hybridum* L. Alsike Clover. Camp Muskingum, Carroll Co. Fay Given.

1330. *Sedum ternatum* Mx. Wild Stonecrop. Geauga Co. H. C. Beardsley and Fred J. Tyler. Camp Muskingum, Carroll Co. Fay Given.

1340. *Chrysosplenium americanum* Schwein. Golden Saxifrage. Norton, Delaware Co. Trella Halderman. Crawford Co. Mary Hemmerly.

1374. *Ilex opaca* Ait. American Holly. Fairfield Co. Escaped. Charles R. and William Goslin.

1375. *Ilex verticillata* (L.) Gr. Winterberry. Carroll Co. Harold S. Vasbinder.

1391. *Schmaltzia crenata* (Mill.) Greene. Fragrant Sumac. Alexander Twp., Athens Co. Walter P. Porter.

1405. *Morus alba* L. White Mulberry. Berne Twp., Fairfield Co. Charles R. Goslin.

1406. *Toxylon pomiferum* Raf. Osage-orange. Lake Co. H. Crofoot and Fred J. Tyler.

1412. *Urtica gracilis* Ait. Slender Nettle. Camp Muskingum, Carroll Co. Fay Given.

1421. *Quercus montana* Willd. Rock Chestnut Oak. Ross Twp., Jefferson Co. Forest Buchanan.

1422. *Quercus bicolor* Willd. Swamp White Oak. Lake Co. H. Crofoot and Fred J. Tyler. Rushcreek Twp., Fairfield Co. Charles R. Goslin and P. J. Miller.

1431. *Quercus coccinea* Wang. Scarlet Oak. Springfield Twp., Jefferson Co. Forest Buchanan.

1433. *Quercus palustris* DuRoi. Pin Oak. Mechanicstown Marsh, Carroll Co. Forest Buchanan.

1456. *Populus alba* L. White Poplar. Kilgore, Carroll Co. Forest Buchanan.

1466. *Salix lucida* Muhl. Shining Willow. Augusta Twp., Carroll Co. Forest Buchanan.

1488. *Hydrangea arborescens* L. Wild Hydrangea. Camp Muskingum, Carroll Co. Fay Given.

1506. *Oenothera biennis* L. Common Evening-primrose. Dundee, Tuscarawas Co. Charles Riley.

1520. *Proserpinaca palustris* L. Mermaid-weed. Salt Creek Twp., Hocking Co. Floyd Bartley.

1532. *Asarum canadense* L. Canadian Wild-ginger. Camp Muskingum, Carroll Co. Fay Given.

1540 *Azalea lutea* L. Flame Azalea. Jefferson Twp., Ross Co. Floyd Bartley.

1543. *Epigeae repens* L. Trailing Arbutus. Carroll Co. Harold S. Vasbinder.

1548. *Gaultheria procumbens* L. Creeping Wintergreen. Carroll Co. Harold S. Vasbinder,

1550. *Pyrola americana* Sw. Roundleaf Wintergreen. Camp Muskingum, Carroll Co. Ethel Harper.

1553. *Chimaphila umbellata* L. Pipsissewa. Good Hope Twp., Hocking Co. Charles R. Goslin and Edward S. Thomas.

1554. *Chimaphila maculata* (L.) Pursh. Spotted Pipsissewa. Carroll Co. Harold S. Vasbinder.

1571. *Polemonium reptans* L. Greek Valerian. Carroll Co. Harold S. Vasbinder.

1582.1. *Phlox subulata* L. var. *australis* Wherry. Southern Ground Phlox. Springfield Twp., Jefferson Co. Forest Buchanan.

1584. *Ipomoea hederacea* Jacq Ivy-leaf Morning-glory. Berne Twp., Fairfield Co. Charles R. Goslin.

1607. *Hydrophyllum virginianum* L. Virginia Waterleaf. Amsterdam, Carroll Co. Forest Buchanan.

1617. *Fraxinus pennsylvanica* Marsh. Red Ash. Ashtabula Co. H. Crofoot and Fred J. Tyler.

1628. *Gentiana andrewsii* Griseb. Closed Gentian. Carroll Co. Harold S. Vasbinder.

1689. *Penstemon hirsutus* (L.) Willd. Hairy Beard-tongue. Springfield Twp., Jefferson Co. Forest Buchanan.

1697. *Mimulus ringens* L. Violet Monkey-flower. Carroll Co. Harold S. Vasbinder.

1721. *Veronica americana* Schwein. American Speedwell. Ross Twp., Jefferson Co. Forest Buchanan.

1726. *Veronica serpyllifolia* L. Thyme-leaved Speedwell. Carroll Co. Harold S. Vasbinder.

1769. *Cynoglossum virginianum* L. Wild Comfrey. Camp Muskingum, Carroll Co. Fay Given.

1771. *Lithospermum latifolium* Mx. American Gromwell. Camp Muskingum, Carroll Co. Fay Given.

1779. *Myosotis arvensis* (L.) Hill. Field Forget-me-not. Pleasant Twp., Fairfield Co. Charles R. Goslin.

1801. *Scutellaria lateriflora* L. Mad-dog Skullcap. Camp Muskingum, Carroll Co. Fay Given.

1813. *Mentha piperita* L. Peppermint. Athens Co. Walter P. Porter and P. S. Wamsley.

1850. *Synandra hispidula* (Mx.) Britt. Synandra. Green Twp., Ross Co. Floyd Bartley.

1887. *Aralia racemosa* L. American Spikenard. Ross Twp., Jefferson Co. Forest Buchanan. Camp Muskingum, Carroll Co. Fay Given.

1889. *Aralia nudicaulis* L. Wild Sarsaparilla. Carroll Co. Forest Buchanan.

1891. *Panax trifolium* L. Dwarf Ginseng. Hocking Co. Floyd Bartley.

1894. *Hydrocotyl americana* L. American Marsh-pennywort. Green Twp., Ross Co. Floyd Bartley.

1908. *Thaspium barbinode* (Mx.) Nutt. Hairy-jointed Meadow-parsnip. Ross Twp., Jefferson Co. Forest Buchanan.

1914. *Heracleum lanatum* L. Cow Parsnip. Lee Twp., Carroll Co. Forest Buchanan.

1929. *Cicuta maculata* L. Spotted Water-hemlock. Camp Muskingum, Carroll Co. Fay Given.

1944. *Houstonia caerulea* L. Bluets. Carroll Co. Harold S. Vasbinder.

1946. *Houstonia ciliolata* Torr. Fringed Houstonia. Amsterdam, Carroll Co. Forest Buchanan.

1951. *Cephalanthus occidentalis* L. Buttonbush. Carroll Co. Harold S. Vasbinder.

1961. *Galium triflorum* Mx. Fragrant Bedstraw. Carroll Co. Harold S. Vasbinder.

1979. *Viburnum dentatum* L. Toothed Arrow-wood. Augusta Twp., Carroll Co. Forest Buchanan.

1981. *Viburnum lentago* L. Sheepberry. Amsterdam, Carroll Co. Forest Buchanan.

2002. *Valerianella locusta* (L.) Bettke. European Corn-salad. Hocking Co. Floyd Bartley.

2004. *Valerianella radiata* (L.) Dufr. Beaked Corn-salad. Amsterdam, Carroll Co. Forest Buchanan.

2014. *Specularia perfoliata* (L.) A. DC. Venus'-looking-glass. Ross Twp., Jefferson Co. Forest Buchanan.

2015. *Lobelia cardinalis* L. Cardinal Lobelia. Lake Co. Fred J. Tyler.

2112. *Antennaria plantaginifolia* (L.) Rich. Plantain-leaf Everlasting. Orange Twp., Carroll Co. Forest Buchanan.

2114. *Antennaria neodioica* Greene. Smaller Everlasting. Brush Creek Twp., Jefferson Co. Floyd B. Chapman.

2120. *Solidago bicolor* L. White Goldenrod. Springfield Twp., Jefferson Co. Forest Buchanan.

2122. *Solidago flexicaulis* L. Zig-zag Goldenrod. Springfield Twp., Jefferson Co. Forest Buchanan.

2147. *Aster divaricatus* L. White Wood Aster. Amsterdam, Carroll Co. Forest Buchanan.

2167. *Aster lateriflorus* (L.) Britt. Starved Aster. Springfield Twp., Jefferson Co. Forest Buchanan.

2170. *Aster ericoides* L. Dense-flowered Aster. Dundee, Tuscarawas Co. Charles Riley.

2179. *Erigeron philadelphicus* L. Philadelphia Fleabane. Amsterdam, Carroll Co. Forest Buchanan.

2231. *Senecio aureus* L. Golden Squaw-weed. Carroll Co. Harold S. Vasbinder.

2242. *Articum minus* Schk. Common Burdock. Camp Muskingum, Carroll Co. Fay Given.

2276. *Hieracium paniculatum* L. Panicled Hawkweed. Lake Co. Fred J. Tyler.

A STUDY OF THE BIOLOGY OF CHELONELLA SULCATA NEES
(HYMENOPTERA: BRACONIDAE)

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INTRODUCTION

Chelonella sulcata Nees is a braconid belonging to the subfamily *Cheloninae.* It is a parasite of some of the most notorious cotton pests in Egypt (e.g., *Platyedra gossypiella* Saunders, *Ephestia kuehniella* Zeller and others). No important studies have been made on this species. This report represents a laboratory study of the biology of *Chelonella sulcata* Nees in Egypt.

The host used in this study was *Ephestia kuehniella* Zeller. *Chelonella sulcata* also was reared successfully in the laboratory from *Earias insulna* Bois., and *Platyedra gossypiella* Saunders.

MORPHOLOGY

Egg—(Pl. I. 1, 2). The length of the egg at oviposition equals 0.154 mm. and the width is 0.0567 mm. The egg of *C. sulcata*, immediately after deposition inside an *Ephestia* egg, is cylindrical, arcuate, or kidney-shaped. It is translucent, white in color, and has a smooth, glistening surface. As development proceeds, the egg becomes distended and the cephalic end broadens, but the length remains the same.

First-Stage Larva—(Pl. I. 3, 4). At eclosion the length is 0.36 mm., the head width 0.084 mm., the first thoracic segment width 0.062 mm., the first abdominal segment width 0.059 mm., and the length of the mandible 0.04 mm.

When 12 days old the total length is 0.084 mm., the head width 0.08 mm., the first thoracic segment width 0.24 mm., and the first abdominal width 0.23 mm.

The newly-hatched larva has a creamy-white body with eight well defined segments, the first of which is very large in proportion to the rest of the segments, and represents the head. This rather square head is followed by three thoracic and four distinct abdominal segments. The last abdominal segment is two times the length of any of the other segments and may be regarded as a division, since it probably represents several true, but as yet undifferentiated, segments. The anal segment is further lengthened into a blunt appendage.

The 12-day old larva differs considerably from the newly hatched larva. The head remains nearly the same size, while the body segments have enlarged. There are three thoracic and six abdominal segments. The first thoracic segment is relatively large and is at least 3.5 times as long as either of the following two segments. This segment probably represents the first thoracic segment since it does not further divide. The last abdominal segment is nearly five times as long as any of the other abdominal segments and bears on its dorsal surface a cap-like swelling which later continues to evaginate to form the anal vesicle.

Second-Stage Larva—(Pl. I. 5). Larval length near the end of this stage is 3.15 mm., greatest width 0.84 mm., head width 0.52 mm., length of mandible 0.10 mm.

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I also wish to thank Dr. Alvah Peterson, Professor of Entomology, The Ohio State University, for help in the preparation of the manuscript.

The larva is now crescent-shaped, with a spherical body destitute of spines. It possesses a rounded head followed by twelve segments, i.e., 3 thoracic and 9 abdominal, not counting the anal vesicle, which is well developed in this stage. The larva is more opaque and has a creamy color. The old skin or exuvium of the first-stage larva is attached to the posterior end of the last abdominal segment.

Third- (Last-) Stage Larva—(Pl. I. 6). The length after external feeding period is completed is 6.5 mm., the width 1.9 mm., mandible length 0.147 mm., and the average length of the large dorsal spines 0.098 mm.

Upon issuance from the host, the larva is cylindrical and possesses 14 body segments. The body is creamy in color and the skin is thickly covered with minute blunt spines. Dorsally on each of the abdominal segments 1–9, inclusive, are located a few long and dark-brown chitinized spines. These spines occur on each of the nine segments in two short, transverse rows, one on each side of the dorsomeson. Those spines on the dorsomeson have the greatest length.

There are rather large lateral lobes on the first 9 abdominal segments produced by the arrangement of the muscles in that part of the body. Eight spiracles are located on the lateral aspects and near the anterior margin of the second thoracic and first 7 abdominal segments.

After completing its external feeding, the larva is plump, with the lateral lobes distinctly swollen. The color varies from cream to light brown.

Pupa—(Pl. I. 7). The length of the pupa is 4.3 mm., and its width 1.6 mm.

The pupa is of the exarate type, with the legs, wings and antennae free. During this stage it exhibits no movement. For the first four or five days, about half of the pupal period, it is pale yellow in color. The color gradually darkens during the later half of the pupal stage.

Adult—(Pl. II. 8). The length of the imago is 4.1 mm., and its breadth with the wings extended is 6.7 mm.

It is black in color, with smoky wings. The antennae are filiform with sixteen segments in the female and twenty-three in the male; The abdomen is covered dorsally and laterally by a single hard, convex sclerite or carapace, which is creamy-white in its anterior half. At the extreme base of the carapace is a small, semicircular black area. The carapace of the male has an apical oval foramen with a breadth of from 1.5 to 2 times the length, where the length equals the perpendicular height on the apex of the carapace. The body is punctured all over by irregular polygonal areas. Each area gives rise to a hair near its center.

BIOLOGY

Oviposition—If the eggs of *Ephestia* are exposed to the females of *Chelonella* for a period of 24 hours, eggs of the parasite will be deposited within the host eggs. The number of *Chelonella* eggs deposited within an egg of *Ephestia* varies according to the number of the host eggs exposed. When the *Ephestia* eggs are few in number, the number of *Chelonella* eggs deposited per host egg is large.

The *Chelonella* eggs hatch within the egg of *Ephestia*. The hatching period varies with the temperature. It takes 3 to 5 days at 20° C. and 2 days at 28° C. The hatching period of the host eggs (*Ephestia*) takes seven days at 20° C. and four days at 28° C.

Apparently all of the *Chelonella* eggs deposited within the host egg hatch. In some cases as many as nine larvae were dissected out of a single *Ephestia* egg, but only one survives (see section on larval development) and completes its development.

A pre-oviposition period or mating are not essential to egg-laying. The female *Chelonella*, upon emergence from the cocoon, has within her ovaries a number of well developed eggs, which she will deposit at once, if provided with host eggs.

A *Chelonella* female moving about in a cage containing a card of *Ephestia* eggs, appears to note the presence of host eggs when she is about one to two cm. from them. She waves her antennae rapidly, rubs her body and hind legs with her wings, and approaches the eggs. Immediately the antennae are lowered with the tips flattened against the card containing the eggs. The antennae are pushed forward until they encounter the eggs and then the tips are brushed over the surface of one of the eggs. The female draws her body directly forward a short distance and at the same time unsheaths her short ovipositor and inserts it vertically into the egg. During oviposition the female stands motionless over the host egg with her antennae extended straight out before her and bent slightly downwards; the abdomen is at a 90° angle with the rest of the body and the wings on a straight line with the thorax and the head. The first movement following the deposition of the eggs are, a withdrawal of the ovipositor, straightening of the abdomen and a slight vibration of the antennae. The female then turns around, searching for another egg, and the process is repeated. This procedure is repeated until every egg on the card is parasitized or until the female has deposited all of the mature eggs contained in her ovaries, as verified by dissection.

Pierce and Holloway (1912), describing the parasitizing of eggs of *Laphygma frugiperda* (A. & S.) by *Chelonus texanus* Cress., mentioned the moving forward of the abdomen just prior to oviposition, and this was later confirmed by Luginbill (1928). A similar behavior was observed by Vance (1932) during the oviposition of *Chelonus annulipes* Wesm. in the eggs of *Pyrausta nubilalis* (Hbn.).

It takes from 10 to 25 seconds for a regularly ovipositing *C. sulcata* female to lay a number of eggs inside that of *Ephestia*. However, the process often takes several minutes. For example, one *Chelonella* female on her first day of oviposition, was observed to deposit 98 eggs inside 9 host eggs, spending an average of one minute and fifteen seconds at each oviposition. A maximum of three minutes and thirty seconds was required for one deposition and a minimum of ten seconds for another.

The age of the host eggs does not influence the choice of the female in her selection, nor does host egg age influence the development of the parasite.

It has been observed that there is a direct relationship between the rate of oviposition of *Chelonella* and the amount of food consumed. It has been found that when a female *Chelonella* is deprived of food, which consists of honey placed as small drops in a row on each side of the midrib of a *Nerium* leaf, she does not oviposit the normal number of eggs. Whereas when the same female was supplied with ample food, the number of eggs oviposited was much greater.

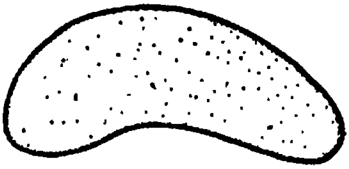
The incubation of the eggs of *Chelonella sulcata* varies with the temperature, the higher the temperature, the shorter the incubation period and vice-versa. One day is the shortest incubation period between March and the end of November. This minimum period occurred in July, whereas the longest incubation period (5 days) occurred during the latter part of March and the beginning of April. Also, the average incubation period is four days during March, three days during

EXPLANATION OF PLATE I

FIG. 1. Chelonella egg just after deposition inside host egg. Length, 0.154 mm.
FIG. 2. Chelonella egg just before hatching. Length, 0.154 mm.
FIG. 3. Dorsal view of first-stage larva just after hatching. AS, anal segment; AP, appendage; H, head; PT, prothorax. Length, 0.26 mm.
FIG. 4. Ventral view of 12-day old first-stage larva. AV, anal vesicle; H, head; LP, labial process; Mn mandible; PT, prothorax. Length, 0.8 mm.
FIG. 5. Lateral view of second-stage larva. AV, anal vesicle; H, head; LM, exuvium of first-stage larval moult. Length, 3.15 mm.
FIG. 6. Lateral view of last-stage larva. A, anus; FS, first abdominal spiracle; H, head; LL, lateral lobe; SS, seventh abdominal spiracle; TS, thoracic spiracle. Length, 6.5 mm.
FIG. 7. Lateral view of late pupal stage. Length, 4.3 mm.
FIG. 8. Dorsal view of adult *Chelonella sulcata.* Length, 4.2 mm. Width of wings stretched, 6.75 mm.

Chelonella sulcata
Albert Abdel-Malek

PLATE I



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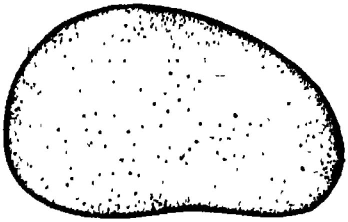

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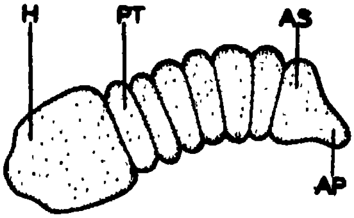

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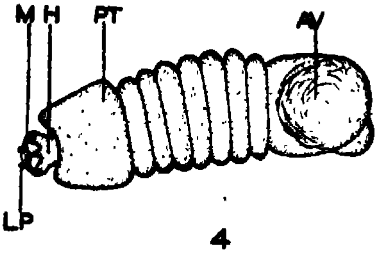

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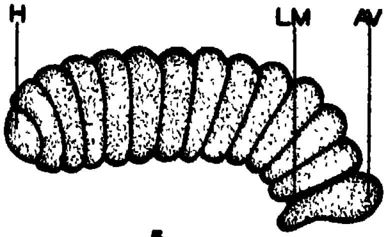

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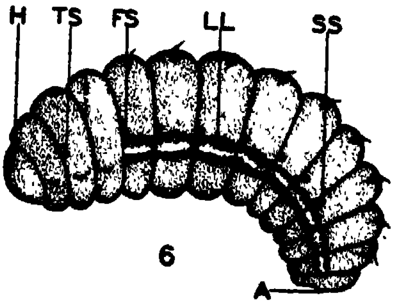

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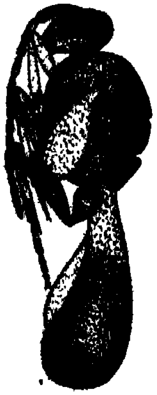

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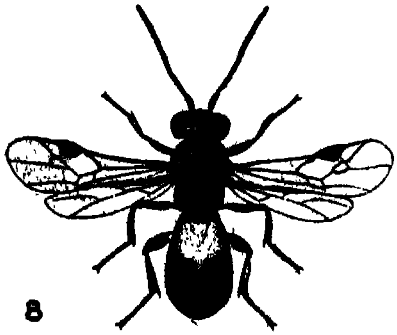

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April, three days during May, two days during June, July, August, September and October, and three days during November.

Effect of Temperature on Oviposition—The temperature at which the females are kept influences oviposition. By working out the minimum and maximum temperatures at which no oviposition took place, it has been found that a temperature of 15° C. is the minimum and a temperature of 40° C. is the maximum. The number of eggs oviposited increased as the temperature rose. It was noted that the females kept at a temperature of 35° C. had died nine days earlier than those kept at 26° C. This indicated that high temperature shortens the life of the insect and also accelerates the rate of oviposition.

Larval Development—The larva of *Chelonella sulcata* is strictly an endoparasite which spends practically all of its life free within the body cavity of the host larva. A general idea of the advancement of the larval development is obtained from numerous host larva dissections coupled with a study of the body size, molted skin, form of the mandibles and widths of the head capsules.

The parasite passes through three distinct larval instars, moulting twice within the host, while the third moult takes place outside the host, within the newly-spun cocoon. The cast skins of the first and second moults are pushed back towards the posterior end of the larva, where they remain attached in the form of a thin dark ribbon at the base of the anal vesicle, especially in the case of the second-stage larva. In both larvae, they remain attached for a short time before they are entirely shed. The third moult takes place within the newly-spun parasite cocoon and can be easily seen at the posterior end of the white silvery cocoon.

The length of the larval stages varies considerably with the temperature. Under constant temperature of 27° C. dissection of about 90 *Ephestia* larvae of different ages containing *Chelonella* parasites showed the length of the larval stages to be approximately as follows: The first stage lasts 16 days, second stage 4 days, last stage (internal) one day and last stage (external) two days, or a total of 23 days. Considerable individual variation occurs in the length of the stages, especially among the first stage larvae for the six generations. Table I gives the average lengths of the three larval stages during the six generations per year.

The *Chelonella* larva of the sixth generation spends nearly three months of the year as a late first-stage larva within the hibernating host larva.

About 200 parasitized *Ephestia* larvae were placed at a constant temperature of 27° C. Nineteen *Chelonella* larvae emerged from these host larvae, averaging 25 days, counting from the time the parasite eggs were deposited until the issuance of the *Chelonella* larvae from the host. The pupation of 40 unparasitized host larvae subjected to the same temperature and reared at the same time, counting from the time the other host eggs were exposed to oviposition by *Chelonella* until the pupae were formed, required an average of 31.3 days. The *Chelonella* larvae had left their host larvae on an average of 6.3 days earlier than the latter normally pupated.

As has been noted before, *Chelonella* oviposits within the eggs of *Ephestia* and all of the eggs hatch within the host egg. As many as fourteen parasite eggs have been dissected from one *Ephestia* egg. When the host eggs hatch, not more than two parasite larvae can be found within the host. This condition does not last long, for within 24 hours after the *Ephestia* has hatched, only one of the *Chelonella* larvae survives. Great numbers of dissections have never shown more than one second-stage larva per host. Also in rearing many hundreds of individuals, not more than one mature parasitic larva has emerged from a single parasitized host.

Issuance of Last-Stage Larva and its External Feeding—Prior to issuance of the last stage larva of *Chelonella* from its host, the parasitized *Ephestia* larva spins a very loose, oval coooon which is strengthened in part by food particles of coarse crushed maize (corn meal). About one-third of the cocoon is free of maize particles and remains a thin silky sheet through which the larva can be seen. The color of *Ephestia* larvae changes from yellowish-brown to creamy-white. It becomes plump and develops an appearance similar to that of an undersized prepupa. On dissection of such a parasitized larva, the third stage larva of *Chelonella* is seen lying with its ventral surface against the dorsal wall of the host larva. Also its head is directed cephalad to the *Ephestia* larva. After transforming into the last stage, the parasite larva remains from half to one day within the host larva. By means of its powerful dentated mandibles, it eats its way out through an incision in the dorsal integument of the host.

After making an incision in the dorsum of the host larva with its mandibles, the parasite larva protrudes its head from the opening, followed by the rest of the body. The head and body segments are directed towards the posterior end of the host larva. When all the abdominal segments are withdrawn from the host, the *Chelonella* larva begins its external feeding at some point on the dorsal surface near the caudal end of the host larva. Then it curls its head to the right or left, followed by the rest of the body segments, and moves slowly towards the cephalic end of the host larva. During its movement, it makes other incisions in the body and continues its feeding upon the internal organs of the host larva.

TABLE I

AVERAGE LENGTH OF THE THREE LARVAL INSTARS OF *Chelonella sulcata* DURING THE SIX GENERATIONS ANNUALLY

Generation Number	Average Temp. During Generation	Maximum Temp During Generation	Minimum Temp. During Generation	Average Length of Time of			Average Length of Larval Stages	Maximum Duration of Larval Stages	Minimum Duration of Larval Stages
				First Stage Larva	Second Stage Larva	Third Stage Larva			
	In degrees centigrade	In degrees centigrade	In degrees centigrade	Days	Days	Days	Days	Days	Days
First.......	21.47°	27.0°	17.0°	31	5	3	39	45	38
Second	26.2°	29.5°	23.5°	28	5	3	36	40	35
Third........	28.0°	29.0°	26.5°	18	4	3	25	25	24
Fourth......	26.7°	29.0°	26.0°	16	4	2	22	24	22
Fifth.........	23.9°	28.0°	21.0°	44	5	3	52	64	36
Sixth.	22.4°	23.0°	21.0°	83	5	3	91	96	88

After completing its external feeding, which takes from 24 to 48 hours, nothing remains of the host larva except the empty skin and the chitinous exoskeleton of the head. The *Chelonella* larva becomes more rounded and when dissected, the peritrophic membrane is found full of pieces of the host trachea, fat, alimentary canal and other parts of the internal organs of the host larva.

Cocoon Formation—A few days before the last stage larva of *Chelonella* issues from the body of the host larva, the host spins a thinly constructed cocoon which some writers call the "death-cell." After the parasite larva finishes its external feeding, it rests quietly for about 24 hours. It then starts spinning its cocoon within this so-called death-cell of the host. The construction of the cocoon takes from a half to one day.

The cocoon is constructed of silk white threads, coming out of the external opening of the common silk duct situated on the upper border of the labium of the last-stage larva. The larva, during cocoon construction, moves its head upwards, downwards, forwards and backwards. The silk threads which emerge in a semi-liquid state are gradually woven into a silver-white papery cocoon.

This cocoon is loosely spun exteriorly, but more tightly woven towards the interior, and is attached by the outer threads to the "death-cell." The head capsule and dry skin of the host larva are found outside the cephalic region of the parasite cocoon between the latter and the "death-cell."

A number of experiments were made to determine the effect of external factors on the parasite larva during cocoon formation and pupation. If after its external feeding, the *Chelonella* larva is transferred from its place to a glass tube containing fresh, finely crushed maize, the larva being deprived of its host cell, does not spin its normal cocoon. Much silk comes out of the silk glands, and is woven around the larval head in an irregular fashion which produces a cap over the head. The larva does not live long, usually dying two days before it would normally pupate. In general, it can be said that any disturbance of the parasite larva when it is ready to spin a cocoon, upsets cocoon formation and produces an abnormal distribution of silk which in the end results in death.

Pupal Development—The cocoon of the parasite is spun in about 24 hours and, when finished, the larva ceases movement and rests quietly while transformation begins. One may observe with difficulty through the semi-transparent cocoon the changes the larva undergoes. The thorax and the head become distended and a slight constriction appears between the thorax and the abdomen. The eyes become pigmented and visible and the appendages also appear. This is the prepupal stage common to Hymenopterous parasites. Shortly thereafter, the meconium of the larva is expelled. The prepupal stage does not last more than a few hours and it is difficult to observe. The appendages of the pupa become more and more visible underneath the prepupal skin. The prepupal skin then splits from six to twelve hours after the casting of the larval meconium, beginning at the top of the head and slipping slowly posteriorly, revealing a pale yellow pupa with its perfect appendages. The casting of the larval meconium can be taken for practical purposes to indicate the beginning of the pupal stage. The emergence of adult *Chelonella* from the cocoon may be considered as the end of the pupal period, though the imago may remain within the cocoon a short time after it has been completely formed.

The *sulcata* pupa lies in the posterior two-thirds of the cocoon with its abdominal tip more or less submerged in the larval meconium which is a grayish-black semi-liquid substance located within the inner wall of the cocoon at its caudal extremity.

During development, the color changes of the pupa are distinct. During the first four or five days, or about half of the pupal period, it is pale yellow in color. During the latter half of the stage, the body darkens gradually. The eyes and ocelli in the early stages are light brown and gradually darken to brown. The antennae, head, thorax and the dorsum of the posterior half of the abdomen change from pale yellow to pale brown, to brown, and then become black. The legs also darken and the wings become smoky, with the stigma and wing veins dark brown. The somewhat protruded ventral part of the abdomen remains pale yellow in color in its anterior half, and the posterior half becomes dark brown. The ovipositor becomes brown-colored.

The effect of temperature upon pupal development is quite evident. A temperature of 8° C. serves to retard pupal development, and too long exposure to such low temperature apparently results in high mortality. An experiment was made to determine the exact length of time that *Chelonella* pupae might be subjected to a low retarding temperature and still obtain satisfactory emergence of adults after the cocoons were again exposed to higher temperatures. Fifty cocoons, containing prepupae or early pupae, were placed in a refrigerator at a constant temperature of 8° C. After 25, 30, 35, 40, and 50 days, ten cocoons were taken out, examined, and placed at a temperature of 27° C. The number of adults that emerged were counted. It is evident from this experiment that most of the pupae remain in an early state of development during their exposure to the low retarding temperature. It appears that 40 days is the maximum length of time that *Chelonella* pupae may be subjected to 8° C. and still emerge after their cocoons were exposed to the higher temperature of 27° C.

Emergence of Adult—Inside the cocoon the black-colored adult is indistinctly visible through the semi-transparent silvery cocoon wall. A cocoon just prior to adult emergence was observed under a binocular microscope. The adult *Chelonella* is oriented with its head a few mm. from the anterior end of the cocoon. When about to emerge, frequent movements of the legs, antennae and wings take place, followed by a pushing forward of the whole body of the insect until the head comes close to the cocoon wall. Then the mandibles of the adult insect begin to tear away the silk threads at the tip of the cocoon. This cutting process continues until a hole is made wide enough for the emergence of the body. The insect then shoves its way gradually through this opening. The head protrudes first, followed by the thorax and then the abdomen. The newly emerged adult is quite dry, vivid, and moves actively about inside the glass vial. The cast meconium of the last larval stage and pupal skin may be found at the opposite end of the cocoon. Adults may emerge anytime during the day or night.

Feeding—Various materials have been tested as food for the adults, including sugar lumps, honey, and sugar solutions in soft cotton. Honey proved to be the most successful food for *Chelonella*.

Parthenogenesis and Unisexual Reproduction—It has been found that fertilization in female *Chelonella sulcata* is neither a stimulus nor an absolute condition for oviposition. Unmated females oviposit readily and all their progeny are females. In all of the breeding tests no males were seen. Generation after generation always produced females. This indicates a state of unisexual reproduction in which females always produce females, without the intervention of males. This phenomenon occurs frequently among the parasitic *Hymenoptera*. Unisexual reproduction is normal in a number of species of *Braconidae*, among which may be mentioned *Apanteles thompsoni* Lyle, *Rogas unicolor* Wesm., *Meteorus japonicus* Ashm., and *Microctonus brevicollis* Hal. Not a single male of *Apanteles thompsoni* Lyle has ever been secured in the large-scale rearings that were made by Vance (1931). Under laboratory conditions, all rearings produced females only. Green cotton bolls collected from the field of the Giza experiment station were brought into the insectary until the parasites emerged. Of 100 *Chelonella sulcata* adults collected, two were males and the remainder females. The two males were placed with two females in glass vials and were subjected to artificial strong light for six hours at 27° C. to encourage mating. Copulation was seen to take place and *Ephestia* eggs were then exposed to these mated females. They oviposited normally in these eggs and the host eggs were reared until the adults of *Chelonella* emerged and all were females. In other words, we have an example of a class of insects in which females are produced almost constantly and the opposite sex is rarely encountered. This type of reproduction among parasitic *Hymenoptera* is known as "thelytoky."

Adult Longevity—*Chelonella sulcata* adults are hardy insects. Forty-eight freshly emerged adults confined in separate glass vials covered with muslin, were subjected to various temperatures and food conditions and observed daily. The data obtained from these observations are shown in Table II. Temperatures 8° C., 15° C. and 30° C. were electrically controlled and were practically constant. The room temperature was that of the laboratory, which ranged between 20° C. and 28° C. while the experiments were in progress. The food consists of honey. Water was provided daily by a water-soaked cotton wick placed in the bottom of the glass vials. The results show that *no* food or water produced the shortest longevity (2 to 5 days), while tests with food and water provided optimum longevity (10 to 33 days). Tests with food alone, 6 to 15 days, and with water alone, 4 to 8 days, gave intermediate results.

The noticeable effect of temperature was a shortening of the life of the individuals kept at 8° C. and supplied with both food and water. Laboratory temperatures which fluctuated around 26° C. at the time of the experiment were very favorable to longevity, provided the adults were given both food and water.

Effect of Parasite on Host—Externally, there appears to be no distinguishable difference between parasitized and non-parasitized host larvae up to and including the third instar. After the third instar, the non-parasitized larvae grow more rapidly and are larger than the parasitized individuals. It has been found that the average length and breadth of non-parasitized larvae is 13.5 and 2.5 mm., and that of parasitized larvae is 6.45 and 1.35 mm. This means that the parasitized larva is smaller in size than the non-parasitized by an average of 7.05 to 1.15 mm.

TABLE II

EFFECT OF VARIOUS TEMPERATURES AND FOOD CONDITIONS ON THE LONGEVITY OF ADULT *Chelonella sulcata*

TEMPERATURE	WITH FOOD AND WATER		WITH FOOD ALONE		WITH WATER ALONE		WITH NO FOOD OR WATER	
	Individuals	Average	Individuals	Average	Individuals	Average	Individuals	Average
	Days	Days	Days	Days	Days	Days	Days	Days
8° C.	10, 12, 18	13 3	9, 8, 6	7 6	5, 6, 4	5	4, 5, 2	3 6
15° C.	20, 25, 19	21.3	8, 12, 11	10.3	6, 8, 5	6.3	3, 4, 3	3 3
30° C.	28, 26, 22	25.3	10, 11, 9	10	7, 5, 8	6 6	2, 3, 4	3
Room	33, 31, 29	31	12, 15, 14	13.6	8, 6, 7	7	3, 2, 5	3 3

*Each of these numbers represents the longevity of one individual confined in a separate glass vial.

The parasite not only effects the size of the host, but also retards its development. In the summer generations, which extend from April to the end of November, the non-parasitized larvae continue their development into the sixth or last larval instar and pupate normally. Those larvae of the same generations, which contain *Chelonella* larvae are so retarded in growth that the parasites issue before the *Ephestia* larvae have entered the last instar. In the winter generation, which lasts from the end of November to the middle of March, both the non-parasitized and parasitized larvae hibernate. The non-parasitized host larvae hibernate as the last instar, and the parasitized individuals hibernate as fourth-instar larvae and are smaller in size than the normal host larvae. During this generation, the parasitized host larvae can be easily separated from the non-parasitized by their size.

The color of the parasitized larvae is pale yellow, and differs from that of the non-parasitized individuals, which are buff-colored.

The parasitized host larva during its inactive stage is enclosed and lies motionless in a light woven cocoon. The third or last stage larva of the parasite finds its way out of the host larva and begins its external feeding, eventually leaving only the shrunken cuticle and chitinized head-parts of the host.

Not a single host larva lived after the emergence of the *Chelonella* last-stage larva. This conclusion was also reached by Vance (1931), in the case of *Apanteles thompsoni* Lyle, parasitic on *Pyrausta nubilalis* (Hbn.) where he said "death is the fate of any larva of *Pyrausta nubilalis* from which *Apanteles* larvae have issued, and in no known instance has pupation of the host followed."

Life History and Number of Generations—The life history of *Chelonella sulcata* was taken from records made under laboratory conditions. *Ephestia kuehniella* was the host used in the laboratory for rearing the parasites. It was found that the life-cycle of *Chelonella* is dependent to a considerable extent upon the rate of development of the host. The number of generations of the parasite corresponds to that of its host. The experiments made during 1943 and 1944 showed that the *Chelonella* female began oviposition directly after emergence, provided it was supplied with eggs of *Ephestia*. If we take the middle of March as a point when the adult parasite comes out from the hibernating larva, and December 5th as the date the parasitic females cease ovipositing, we obtain as many as six generations.

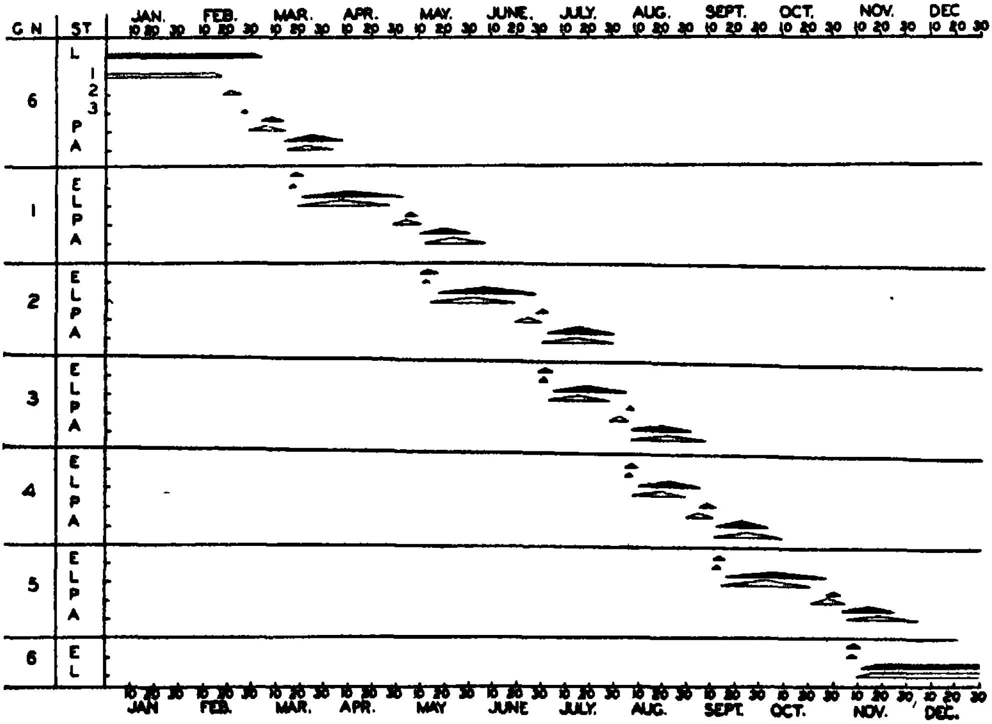

FIG. 1. The duration of stages of both *Chelonella sulcata* Nees (parasite); *Ephestia kueheniella* Z. (host) during the six generations per year and the longevity of the adult in each generation. Host in dark areas.

The relationship between the life history of the parasite *Chelonella* and its host *Ephestia* is clearly demonstrated in Fig. 1, made from data of daily observations over a two-year period.

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SHELLMOUND INDICATING TRACE OF ANCIENT POPULATION FOUND IN SOUTHERN MEXICO

A large shellmound, or "kitchen midden," which may prove to be the first trace of a pre-pottery, pre-agricultural population, has been discovered in southern Mexico by an archeological expedition of the National Geographic Society and the Smithsonian Institution, in cooperation with the Instituto Nacional de Antropologia y Historia of Mexico.

The shellmound was found in the state of Chiapas, in the area of advanced Indian civilizations of southern Mexico and Central America. It is situated on the Pacific coast, bordering a lagoon surrounded by mangrove swamps.

The huge mass contains clam shells, mixed with earth, charcoal and ash, and various objects of human manufacture, piled in a heap about 350 feet long and 250 feet wide and more than 10 feet high.

A test trench dug in the mound produced a few fragments of weathered, rather crude pottery from the uppermost levels. In the lower portion no pottery was found. Only obsidian knives and pieces of worked and shaped animal bones were uncovered to represent the manufactures of the ancient inhabitants.

The scientific importance of the find lies in the fact that the lower levels appear to represent a culture which existed in southern Mexico before the invention of agriculture and pottery-making—that is prior to the archaic beginnings of the high civilizations of the Maya, the Olmec, and the Zapotecs.

The existence of such an ancient hunting and shell-gathering economy has been speculated on by archaeologists who have worked in Middle America, but this is the first discovery that can be attributed to such a culture. Thus, the shellmound may contain the earliest cultural remains yet found in southern Mexico.

The survey party was led by Dr. Philip Drucker of the Smithsonian Institution. The trip was designed to investigate the archeological resources of the coastal plain of Chiapas, which at one time formed a corridor for the exchange and spread of culture between the populations of Central America and those of southern and central Mexico. Little archeological research had previously been done in the region.

Besides the shellmound, numerous sites were found, some of which relate to early phases in the development of Maya culture, and others to later times, not long before the Spanish conquest of the region.

Dr. Drucker previously had served as an assistant to Dr. Matthew W. Stirling of the Smithsonian Institution on a series of National Geographic Society-Smithsonian expeditions to Veracruz State, across the southern Mexican isthmus from Chiapas.

Those expeditions, conducted for eight seasons, resulted in the acquisition of considerable information about the pre-Columbian people of the region. In 1939 the explorers located a stone bearing in Mayan symbols the earliest recorded date found in the Western Hemisphere—November 4, 291 B. C. Among a large number of sculptures uncovered by the expeditions were colossal stone heads. The two largest, discovered in 1946, stand about 10 feet high and are estimated to weigh more than 20 tons each.

ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE
1947

THE OHIO ACADEMY OF SCIENCE

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REPORT OF THE FIFTY-SIXTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

One of the most successful meetings in recent years was held on the campus of Marietta College on May 1, 2, and 3. This was our first visit to Marietta College and we were certainly well received. The Local Committee had provided for every need. Attendance was above average, and programs were presented by all Sections except J.

The meeting opened with the Council meeting on May 1 and sectional meetings were held on May 2 and 3. The annual banquet on Friday evening at 6:30 was attended by more then 200 members and friends. Dr. P. J. Seyler, of the Local Committee, served as an able toastmaster. Greetings were extended by President W. A. Shimer of Marietta College, and response was given for the Academy by Dr. N. W. Hoerr.

The presidential address by Dr. H. H. M. Bowman was on the subject of Antibiosis, in which a review of the history, the preparation of, and the current uses of Antibiotics were presented.

Dr. F. H. Krecker presented plans of a committee appointed last spring to reorganize and reactivate the Junior Academy.

The annual report of the Secretary was presented and this carried an announcement of the election of new members and of the following persons as fellows:

R. C. Allen
S. S. Arnim
R. G. Bossert
Sears Crowell, Jr.
Chas. A. Dambach
W. A. Dreyer
W. A. Everhart
J. O. Fuller
H. S. Greene
W. K. Hale
P. D. Harwood
D. L. Leedy
C. E. MacQuigg
E. F. Paddock
H. G. B. Robinson
E. J. Schaefer
G. L. Stahly
J. R. Van Pelt, Jr.

The announcement was made of the election of Dr. F. O. Grover, of Oberlin, as an Honorary Life Member.

Two amendments to the By-Laws of the Constitution were read by the Secretary and approved by the Academy. (These are referred to in the report of the Council.)

The report of the Nominating Committee was presented by Dr. L. F. Edwards in the absence of Dr. George W. White, and the report of the Resolutions Committee was given by Dr. Nicholas Mogendorff.

Respectfully submitted,

Rush Elliott, *Secretary.*

REPORT OF THE EXECUTIVE COMMITTEE AND COUNCIL

The Executive Committee met on January 17 and again on May 1 and the Council on January 18 and again on May 1.

Two amendments to the By-Laws of the Constitution were received and passed. One is to Chap. III, Sec. 2, a, to read as follows: "A single payment of $100.00 shall excuse a member from all future annual dues and he becomes a Life Member." The other to Chap. IV, 2b, to read as follows: "The Academy shall pay the Ohio Journal of Science the amount of the bill submitted annually for the printing of the annual report and of the presidential address." These amendments were then presented at the annual meeting. (See Report of Annual Meeting.)

The following items relative to finances are of interest: (1) The Treasurer was authorized to invest $200.00 from the Research Fund in a G-bond, the income to be used for research; (2) The Treasurer was instructed to invest $500.00 of current assets in G-bonds.

Reports from all committees were received and are published as a part of the Annual Proceedings.

The report of the Membership Committee is of particular interest. On account of the unusual activity of this committee, 183 new members were added since the last annual meeting. This is probably an all-time high. The applications were duly accepted. Nominations for Fellowship were presented and approved. (See Report of Annual Meeting.)

The Executive Committee presented the name of F. O. Grover for election to Honorary Life Membership. Election was unanimous.

President H. H. M. Bowman presented an invitation to the Academy to hold its 1948 annual meeting at the University of Toledo. The invitation was enthusiastically received and accepted.

Respectfully submitted,

RUSH ELLIOTT, *Secretary.*

REPORT OF THE TREASURER

COLUMBUS, OHIO, July 15, 1947.

To the Ohio Academy of Science:

I submit herewith a financial statement of the condition of the Ohio Academy of Science as of December 31, 1946. The books have been audited and the opinion of the auditor is herewith attached.

Respectfully submitted,

WILBUR M. TIDD, *Treasurer.*

OHIO ACADEMY OF SCIENCE BALANCE SHEET

As at December 31, 1946

ASSETS

CURRENT EXPENSE FUND:			
Cash in Bank			$1,096.14
Bonds owned:			
U. S. War Savings Bond Series F (cost)		$ 111.00	
U. S. War Savings Bond Series G (cost)		1,400 00	
Total Bonds Owned			1,511.00
Total Assets—Current Expense Fund			$2,607.14
RESEARCH FUND:			
Cash in Bank		$ 410.45	
Banc-Ohio Securities Stock		437 50	
Bonds owned:			
Fort Hayes Hotel, Columbus, Ohio (cost)	$1,300.00		
U. S. War Savings Bond Series G (cost)	100 00		
Total Bonds Owned		1,400 00	
Total Assets—Research Fund			2,247 95
TOTAL ASSETS			$4,855.09

LIABILITIES AND NET WORTH

CURRENT EXPENSE FUND:		
Liabilities—		
Accounts Payable		$ 15 00
Deferred Credits—		
1947 Dues Collected in 1946		32 50
Total Liabilities and Deferred Credits		$ 47.50
NET WORTH:		
Ohio Academy of Science—		
Current Expense Fund	$2,559.64	
Research Fund	2,247.95	
Total Net Worth		4,807.59
TOTAL LIABILITIES AND NET WORTH		$4,855.09

OHIO ACADEMY OF SCIENCE STATEMENT OF INCOME AND EXPENSE
For the Year Ended December 31, 1946
CURRENT EXPENSE FUND

INCOME:		
Dues from Membership—		
Regular		$1,372.00
Life Memberships		75 00
Total Dues		$1,447 00
Grants for Research		69 50
Sale of Publications		28 61
Interest on Bonds		17 50
Total Income		$1,562 61
OPERATING EXPENSES:		
Subscriptions—Ohio Journal of Science	$760 50	
Printing Proceedings	155 46	
Research Grants	69.50	
Postage and Office Supplies	88 07	
Clerical Expense	5 50	
Secretary's Honorarium	100 00	
Auditing Expense	15 00	
Bond of the Treasurer	5 00	
Safety Deposit Box Rent	3 60	
Bank Charges	9 25	
Total Operating Expenses		1,211 88
EXCESS OF INCOME OVER EXPENSES		$ 350 73

AUDITOR'S CERTIFICATE

COLUMBUS, OHIO, June 15, 1947.

The Ohio Academy of Science, Columbus, Ohio.
GENTLEMEN:

In accordance with your instructions I have examined the accounts and records of the Ohio Academy of Science for the year ended December 31, 1946.

I hereby certify that in my opinion the books and records kept on a "cash basis" are in accordance with accepted accounting principles.

In my opinion the accompanying Balance Sheet and Statement of Income and Expense for the Current Expense Fund fairly presents the financial condition of the Ohio Academy of Science as at December 31, 1946, and the results of operations for the year ended at that date.

Respectfully yours,

D. M. SHONTING,
Certified Public Accountant.

REPORT OF THE TRUSTEES OF THE RESEARCH FUND

In connection with this report we have to recognize the death of one of the members of the Board, Professor M. E. Stickney, who died since the last meeting. Professor Stickney, long a member of the Academy, was very faithful in service to the Board and though in serious condition from ill health was constant in attention to the duties of the Board.

Grants during the year 1946 have been completed to Doctor M. T. Sturgeon and Doctor H. T. Gier, both of these being allotted from the grant from the A. A. A. S.

The financial statement by the Treasurer, Doctor Tidd, shows that at the end of the year and detailed in his report, $410.45 was credited to the Research Fund of the Academy, and by action of the Executive Committee $200.00 of this amount was to be invested in Government bonds. This leaves a balance of $210.45 available for grants during the coming year, as also the allowance from the A. A. A. S., which may be approximately $150.00.

It may be mentioned that a grant of $100.00 was allotted to Dr. E. Lucy Braun, this being allotted previous to her designation as a Trustee to fill out the unexpired term of Professor Stickney.

Respectfully submitted,

(Signed, Trustees) E. LUCY BRAUN,
J. ERNEST CARMAN,
HERBERT OSBORN, *Chairman.*

REPORT OF THE LIBRARY COMMITTEE

The sales of publications for 1946 including sales tax amounted to $23.04. Thirty-seven copies of fifteen Special Papers and one Annual Report were sold in seventeen sales. Disbursements consisted of $21.00 to the Treasurer of the Academy and 49 cents for 50 sales tax stamps, leaving a balance at the end of the year of $1.55. This has since been given to the Treasurer, together with two checks totalling $21.40 on the sales for 1947.

It was reported last year that the addresses of the foreign exchanges were being replaced on the mailing list of the Ohio Journal of Science as fast as mail service for periodicals was resumed with the various countries and that the back volumes of the Journal had been sent to 151 addresses during the summer of 1945 and would be sent to 64 more in 1946. This was done and the exchange situation is now nearly back to normal. Requests have come frequently from the foreign exchanges for various issues of the recent volumes of the Journal to complete their sets. Such requests are always fulfilled.

The need for a cumulative index to all the volumes of the Ohio Journal of Science and the Ohio Naturalist has been apparent for several years. Work on it was begun last summer, was necessarily discontinued last Fall, but it is hoped that it can be completed and published in 1948.

The length of service of the present librarian of the Academy has now become of age, for it began exactly twenty-one years ago this Spring. As that would seem to be long enough for one person to have the position it might be well for the members of the Council to refer to the Constitution and to consider who would be the logical one to be appointed when the time actually arrives that will make such action necessary.

Respectfully submitted,

Ethel Melsheimer Miller, *Chairman.*

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the Joint Administrative Board of the Ohio Journal of Science was held at Columbus, Ohio, April 24, 1947. The meeting was called to order by Chairman Snyder. Present were Drs. Snyder and White, representing the Ohio State University, and Drs. Blaydes and Miller, representing the Ohio Journal of Science. Drs. Evans and Anderson were unable to attend.

The minutes of the preceding meeting were read and approved.

Upon a motion by Dr. White, which was seconded by Dr. Snyder, Drs. Blaydes and Miller were elected Editor and Business Manager, respectively, for the year 1947-48.

Dr. Blaydes was called upon for the editor's report, a copy of which is herewith attached. A review of the papers presented in Volume 46 followed in which Dr. Blaydes called attention to the wide distribution of several prominent manuscripts published in the Journal during the past year. The editor called to the attention of the Board that the Ohio Journal of Science is available for immediate publication. He is desirous that this information be conveyed to the Council and through the Council to the membership of the Academy.

The Board expressed general approval to the suggestion of the editor, that short papers and notes on current topics be accepted for publication. Dr. Snyder moved the acceptance of the editor's report; this motion was seconded by Dr. Miller, and passed by the Board.

The Chairman next called for a report from the Business Manager. Dr. Miller's report was in the form of a financial statement for Volume 46 of the Ohio Journal of Science, a copy of which is herewith attached. In commenting upon the financial statement, Dr. Miller again directed the attention of the Board to the continued increase in publication costs. The financial statement clearly indicates that if the Journal is to be continued (on the basis of present costs) additional revenue must be provided. As an example:

Printing cost has increased *this* year over *last* year from $2,022.24 to $2,553.43—an increase of $531.19. The Academy, during the past year, contributed $859.50, $277.19 less than the preceding year. (The average Academy appropriation over the past six years is $1,004.87.)

Two items in the financial report were especially cited to the Board, namely, through the efforts of Dr. Blaydes, and the cooperation of Sectional Chairmen, the Journal received $499.54 in publication subsidy. In addition to this amount, $201.08 was received through credit on reprints of several outstanding papers. Notwithstanding this new source of revenue amounting to $700.62, the Journal experienced a net operating loss of $287.43 for Volume 46.

Dr. Miller, at this point, made it clear that similar subsidy was not indicated for the current volume.

At the conclusion of the Business Manager's report it was determined by the Board to request of the Academy additional subsidy, at least equal to that provided by the University. Additional revenue through accepting advertising was discussed but no action taken.

Dr. White moved the acceptance of the report of the Business Manager; this motion was seconded by Dr. Blaydes and passed by the Board.

Drs. Snyder and White were appointed by the Board to audit the accounts of the Journal for the fiscal year just ended.

There being no further business to come before the Board it was adjourned.

Respectfully submitted,

JOHN A. MILLER,
Secretary of the Board.

THE EDITOR'S REPORT TO THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The Ohio Journal of Science, Volume 46, 1946:

Total number of pages printed in Volume 46	344
Number of papers in Volume 46	52
Distribution of papers by subject:	
Botany	3
Entomology	12
Genetics	1
Geography	1
Geology	4
Medicine	27
Ohio Academy of Science, Annual Report	1
Zoology	3
Total	52 papers
Book Reviews	8

FINANCIAL REPORT OF THE OHIO JOURNAL OF SCIENCE—FISCAL YEAR 1946

RECEIPTS

Balance from 1945	$ 539 08
University Allowance	1,000.00
Ohio Academy of Science—pro rata of dues	760.50
Ohio Academy of Science—Payment of previous obligation (1943)	99 00
Subscriptions	131 00
Sale of back numbers	87.80
Author's Payment of Plates	56.18
Four Continent Book Co. (change from domestic to foreign rate)	1.75
Graduate School, O. S. U. (Harley Brown paper)	224.54
O. S. U. Medical Symposium Number	200.00
E. L. Moseley paper	75.00
Credit on reprints (Spahr and Glenn)	201 08
	$3,375.93

EXPENDITURES

Spahr and Glenn (printing, Volume 46)	$2,553.43
Bucher Engraving Company, (Volume 46)	351.89
Postmaster (Unpaid balance of 1945)	34.90
Postmaster (Foreign exchanges)	62.80
Postmaster (Current volume)	100.75
Bank charges	.51
Clerical assistance	20.00
	$3,124.28
Balance on hand, March 1, 1947 (Huntington National Bank)	251.65
	$3,375.93

REPORT OF THE COMMITTEE ON CONSERVATION

The Committee on Conservation presents the following report:

1. There is need for more extensive surveys of the natural resources of Ohio.
2. There is need for better correlation of the several surveys of Ohio's natural resources.
3. There is need for an integrated attack upon the problems presented by those who seek to promote public acceptance of the facts about our natural resources and their wise use which are revealed by research.
4. There is need for attack on the problems inherent in gaining administrative use of the facts revealed by scientific research.

The Committee on Conservation recommends that the Ohio Academy of Science should proffer its services, as an organization, and as individuals who are influential in guiding public thinking in many Ohio Communities, toward promoting the more efficient administration of Ohio's natural resources by helping to meet these needs.

Respectfully submitted,
G. W. CONREY,
C. L. DOW,
ROSCOE FRANKS,
ARTHUR HARPER,
E. W. E. SCHEAR,
C. E. TAFT,
G. W. WHITE,
E. L. WICKLIFF,
T. H. LANGLOIS, *Chairman.*

REPORT OF THE COMMITTEE ON NECROLOGY

The Committee on Necrology reports with deep regret the death of three members of the Academy since the last annual meeting. The following biographical material was furnished by colleagues on the respective university faculties.

MALCOLM ENOS STICKNEY

Malcolm Enos Stickney, professor-emeritus of botany at Denison University, died of coronary thrombosis at his home in Granville, June 15, 1946, after an illness of several months. He had been in failing health during the past few years.

Born April 18, 1874, in Brownville, Me., he attended high school there, later graduating from Nichols Latin School. He took a Bachelor of Arts degree from Bates College in 1898 and the next two years attended Harvard University, earning both Bachelor and Master of Arts degrees there. He did further graduate study at the University of Wisconsin and at the Marine Biological Laboratories, Woods Hole, Mass. Joining the faculty at Denison in 1903, he served one year as instructor, five as assistant professor, and was professor and head of the department from 1909 until his retirement in 1940. For 20 years he taught at the Ohio State Biological Laboratories at Put-In-Bay on Lake Erie. He also served for many years as examiner for the health department of Licking County, making bacteriological diagnoses, and laboratory tests and examinations for local physicians. After his retirement and before his health failed, he spent many hours in the laboratory identifying specimens in the world-wide collection of ferns bequeathed to the college by the late Wallace Cathcart, who had been an alumnus and trustee.

Professor Stickney was a member of several learned and scientific societies, including the American Association for the Advancement of Science, the Botanical Society of America, the Ecological Society of America, the American Microscopical Society, and the Botanists of the Central States. He served the Ohio Academy of Science as vice-president for two years and the Denison Scientific Association as president for two years. At the time of his death he was a Trustee of the Research Fund of the Ohio Academy of Science. He was a member of Kappa Sigma fraternity and of Phi Beta Kappa, national scholastic honorary fraternity.

FRANCIS J. MOLZ

Dr. Francis J. Molz, S.M., associate dean and head of the division of science at the University of Dayton, died unexpectedly September 3, 1946, of a heart attack.

A native of Baltimore, Md., Dr. Molz joined the Society of Mary in Dayton in 1907, and made his first profession of vows March 25, 1908. He received his Bachelor of Science degree from the University of Dayton in 1916 and a licentiate in science and a Doctor of Philosophy degree from the University of Fribourg, Switzerland, in 1923 and 1924. He joined the faculty of the University of Dayton in 1924 and began teaching in the biology department which he later headed. Dr. Molz was faculty adviser of Sigma Delta Pi, pre-medical society and also a member of the university athletic board. Dr. Molz became associate dean and head of the division of science in 1935. During his term and under his leadership the university completed arrangements for affiliation with St. Elizabeth's Hospital School of Nursing, and also the Miami Valley Hospital's medical technology school and laboratory. The department of home economics at the university was also established as a section of the science division during Dr. Molz's administration.

Brother Molz was a member of the American Association for the Advancement of Science, Ohio Academy of Science, and Ohio Health Association.

JOSEPH HARVEY GOURLEY

Joseph Harvey Gourley, professor and head of the department of Horticulture and Forestry at Ohio State University, died on October 27, 1946.

Born July 1, 1883, in Homer City, Pa., he received the degrees of Bachelor of Science and Master of Science from Ohio State University in 1908 and 1915, respectively. The degree of Doctor of Philosophy was conferred upon him by the University of Chicago in 1931. He was long associated with the Ohio Experiment Station, holding the position of Chief of the Department of Horticulture from 1921 until his death. He also held professorships in Horticulture at West Virginia University and at the University of New Hampshire and from 1912-1920 was vice-director of the New Hampshire Experiment Station. In 1920 he became professor and head of the Department of Horticulture and Forestry at the Ohio State University.

Dr. Gourley was Associate Editor of the American Fruit Growers Magazine, a member and former president of the Society of Horticultural Science, and a fellow of the Ohio Academy of Science. His chief professional interests were in the fields of fertilization in orchards; flower-bud formation; pomology; and orchard management.

Respectfully submitted,

A. C. Anderson,
F. G. Detweiler,
R. V. Sinnett, *Chairman.*

REPORT OF COMMITTEE ON RESOLUTIONS

Be it Resolved, that, since the reduction in the budget of the Department of Interior endangers the program of conservation research, the Ohio Academy of Science convey to the proper authorities through its Secretary the urgency of continuing support of this program as now organized in the State of Ohio.

Be it further Resolved, that the members of the Academy express their gratitude and appreciation to President Shimer and to the faculty of Marietta College for the hospitality and courtesies extended; and

Be ir further Resolved, that the members of the Academy express their indebtedness to the local Committee on Arrangements, which under the leadership of Professors H. R. Eggleston and P. J. Seyler has provided such excellent facilities for the meeting, and which has made our stay at Marietta most comfortable and pleasant; and

Be it further Resolved, that the Ohio Academy of Science express to its librarian, Mrs. Ethel Melsheimer Miller, its deep appreciation and gratitude for her devoted service during the past twenty-one years.

Be it further Resolved, that the members of the Academy express their sincere thanks to their President, Dr. H. H. M. Bowman, whose untiring efforts contributed greatly to make this fifty-sixth annual meeting a success.

Respectfully submitted,

N. L. Hoerr,
E. W. E. Schear,
N. Mogendorff, *Chairman.*

THE OHIO JOURNAL OF SCIENCE

VOL. XLVII NOVEMBER, 1947 No. 6

AREAL EXTENT AND THICKNESS OF THE SALT DEPOSITS OF OHIO[1]

JAMES F. PEPPER
U. S. Geological Survey, New Philadelphia, Ohio

INTRODUCTION

Beds of rock salt occur in Ohio in rocks of the Salina formation of the upper Silurian. Since 1889 salt has been manufactured commercially from these beds by pumping fresh water into wells drilled to the salt beds and repumping the brine to the surface, where it is processed. Salt, which is one of the basic raw materials of the chemical industry, is a commercial resource of great and increasing value to Ohio.[2] [3] [4]

In order to furnish information that may be useful to operators desiring suitable locations for salt plants, a regional study has been made to determine the western limits of the occurrence of beds of salt in Ohio, the total thickness of salt beds within the area of occurrence, and the depth to the top of the highest salt bed in the section at any place. The study is based on an examination of the records of salt beds contained in well logs in the files of the U. S. Geological Survey and on the results of examinations of samples by R. E. Lamborn of the Geological Survey of Ohio. No attempt is made in this report to discuss the general stratigraphic correlations of the Silurian salt sequence of Ohio to the salt-bearing Salina formation of Cayuga (Silurian) age of other areas, or to suggest the possible origin and manner of deposition of the salt.

ACKNOWLEDGMENTS

The drillers' records of wells used in compiling the salt data were obtained from the Ohio Division of Mines and the Geological Department of The Ohio Fuel Gas Company. The cooperation of these organizations is gratefully acknowledged. The writer gratefully acknowledges the assistance and kind criticism of Dr. George White and Mr. R. E. Lamborn of the Geological Survey of Ohio. Mr. Lamborn supplied the records of sample wells which he had examined, together with much assistance in the calculation of the estimated original thicknesses of the several salt beds. Messrs. H. D. Miser, C. H. Dane, and R. E. Van Alstine of the U. S. Geological Survey kindly read and criticized the manuscript. The writer wishes to thank Mrs. Violet M. Massarelli for her assistance in compiling the data on which the report was based and for drafting the accompanying maps.

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[1] Published by permission of the Director, U. S. Geological Survey, and the State Geologist of Ohio.

[2] Hildreth, S. P. Salt Springs: Early History of Salt Manufacture in Ohio, [reprint] in Ohio's Mineral Resources, III. Salt: Ohio State Univ. Eng. Exper. Sta. Circ. no. 47, vol. XIV, no. 2, pp. 1–12, July, 1945.

[3] Harris, W. R., and Corell, E. J. Industrial Development of Salt Manufacture in Ohio, in Ohio's Mineral Resources, III. Salt: Ohio State Univ. Eng. Exper. Sta. Circ. no. 47, vol. XIV, no. 2, pp. 13–19, July, 1945.

[4] Gambs, G. C., and White, G. W. Ohio's Mineral Resources, III. Salt reserves (Third in a series on salt): Ohio State Univ. Eng. Exper. Sta. Circ. no. 49, vol. XV, no. 3, pp. 1–22, September, 1946.

DATA UPON WHICH THE STUDY WAS BASED

The data on which this study was based were derived chiefly from an examination of the records of 3,555 wells drilled for oil or gas to the horizon of the Clinton sand, which lies below the salt series in east-central Ohio. In eastern Ohio along the Ohio-Pennsylvania border few wells have been drilled through the salt series, and drilling information is thus available at only widely scattered points. The following table shows the number of well records examined:

NUMBER OF WELL RECORDS, TO THE CLINTON SAND, USED IN COMPILING SALT DATA

County	From U. S. Geological Survey Files		From Sample Records by R. E. Lamborn†
	Total Number	Number which Record Salt	
Ashtabula	37	16	3
Belmont	1	1	1
Carroll	4	4	1
Columbiana	5	4	.....
Cuyahoga	20	13	.....
Geauga	12	8	....
Harrison	12	10	2
*Holmes	702	12	......
Lake	19	14	1
Mahoning	6	2	1
Medina	210	54	.....
Portage	16	12	......
Stark	794	755	2
Summit	245	182	...
Trumbull	13	11	1
*Tuscarawas	244	184	3
Washington	1	1	......
*Wayne	1,214	113	.....
Totals	3,555	1,396	15

*Salt is not present west of a line which passes through the county.
†See logs at end of report.

The table shows that no salt is recorded in many drillers' records of wells within the area of salt deposition in Ohio. Salt may not have been present in some of the wells, but it is doubtful that salt beds are absent over extensive areas. Probably most of the wells passed through beds of salt, but the driller failed to observe these beds because they are thin, or, if thick, are interbedded with dolomite, anhydrite, or shale. The salt cuttings in a well being drilled may go into solution in the water which is used in drilling or become mixed with mud, and thus may escape notice when bailed from the well. The driller probably would record salt when the contact between a hard bed, such as dolomite, above and thick salt bed below was sharp, for the bit would have a tendency to penetrate more easily when it reached the salt. Some drillers recorded from one to four beds of salt; in the same area others recorded the top of the uppermost salt bed and the bottom of the lowest salt bed and thus logged as salt the entire sequence of rocks, which in reality included also beds of dolomite, limestone, anhydrite, and shale.

The determination of the thickness of salt beds from an examination of samples taken through the salt series is difficult, for much of the salt is dissolved by the water used in drilling. Usually samples are taken at intervals of 6 to 10 feet, and if only enough salt is present to saturate the water the samples may consist mostly of dolomite and anhydrite together with a few fragments of salt or salt crusts which are deposited upon the cuttings as the water evaporates. The beds represented by such a sample may thus consist mainly of salt, the dolomite and anhydrite being present only as thin beds. However, the presence of salt and an estimation of the thickness of the salt beds can be much more accurately determined from well samples than from the driller's log.

OCCURRENCE OF THE SALT

The oldest salt beds throughout the region of southern New York, western Pennsylvania, northern West Virginia, eastern Ohio, Michigan, and southwestern Ontario were deposited in local isolated basins. For example, the oldest salt beds in Ohio were deposited in the deeper part of a basin in Portage and Columbiana Counties. As deposition of salt continued, each basin increased in size until near the end of Salina time the basins became connected and salt was deposited throughout the region. Over a broad area in eastern Ohio some of the salt beds, although apparently nearly continuous by correlation based on position in the section, are probably not strictly equivalent in time of deposition.

The salt beds of the Ohio salt basin occur in the central part of a thick section of limestones and dolomites. The drillers call this sequence of beds the Big Lime, because the drilling characteristics of limestone and dolomite are not sufficiently different to distinguish one from the other and because the muds bailed from wells drilling in this sequence of rocks have a gray color similar to lime muds. Stratigraphically in Ohio the Big Lime includes from the top down, the Delaware limestone, Columbus limestone, and Detroit River dolomite (all Devonian); the Bass Island dolomite (Silurian); the "bed of rock salt with some shale and interbedded dolomite, all of which probably represent the Salina group"[5] (Silurian) and the dolomites of the Niagara limestone (Silurian). The limestones and dolomites have been described from outcrops west of the salt area, but the salt beds are known only from subsurface information. In eastern Ohio along the Pennsylvania border some of the subsurface beds are correlated with, and named after, beds that crop out in New York and Pennsylvania. Thus, the term "Onondaga limestone" is used in eastern Ohio to describe the Devonian limestone of the Big Lime above the salt. On paleontological evidence the Onondaga limestone at outcrops in New York and Pennsylvania is apparently equivalent only to the Columbus limestone.

The amount of shale in the salt series varies from place to place. Although much shale is recorded in the salt beds by the drillers, Lamborn found from his sample examination that much of the so-called shale is either very thin bedded argillaceous dolomite or limestone. Sample records are too few in the salt basin to indicate the area in which the greatest amounts of dolomite, anhydrite, and shale are interbedded with the salt, but in general these other rocks appear to increase in proportion eastward.

WESTERN LIMIT OF SALT DEPOSITION

The western limit of salt deposition in Ohio is shown by the zero thickness line on the maps (figs. 1, 2). In Medina, Wayne, and Holmes Counties, the location of this line is based upon the examination of the records of many wells. In these counties the zero line was drawn at places where more than 75 per cent of the well logs contained no record of salt. In Lorain and Tuscarawas Counties the zero line is less accurately determined because fewer well records were available. South of Tuscarawas County in Guernsey, Noble, and Washington Counties where very little information is available, the zero line is only approximate.

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[5] Lamborn, R. E. Data on the thickness and character of certain sedimentary series in Ohio: Ohio Jour. Sci., vol. 34, no. 6, pp. 353–354, November, 1934.

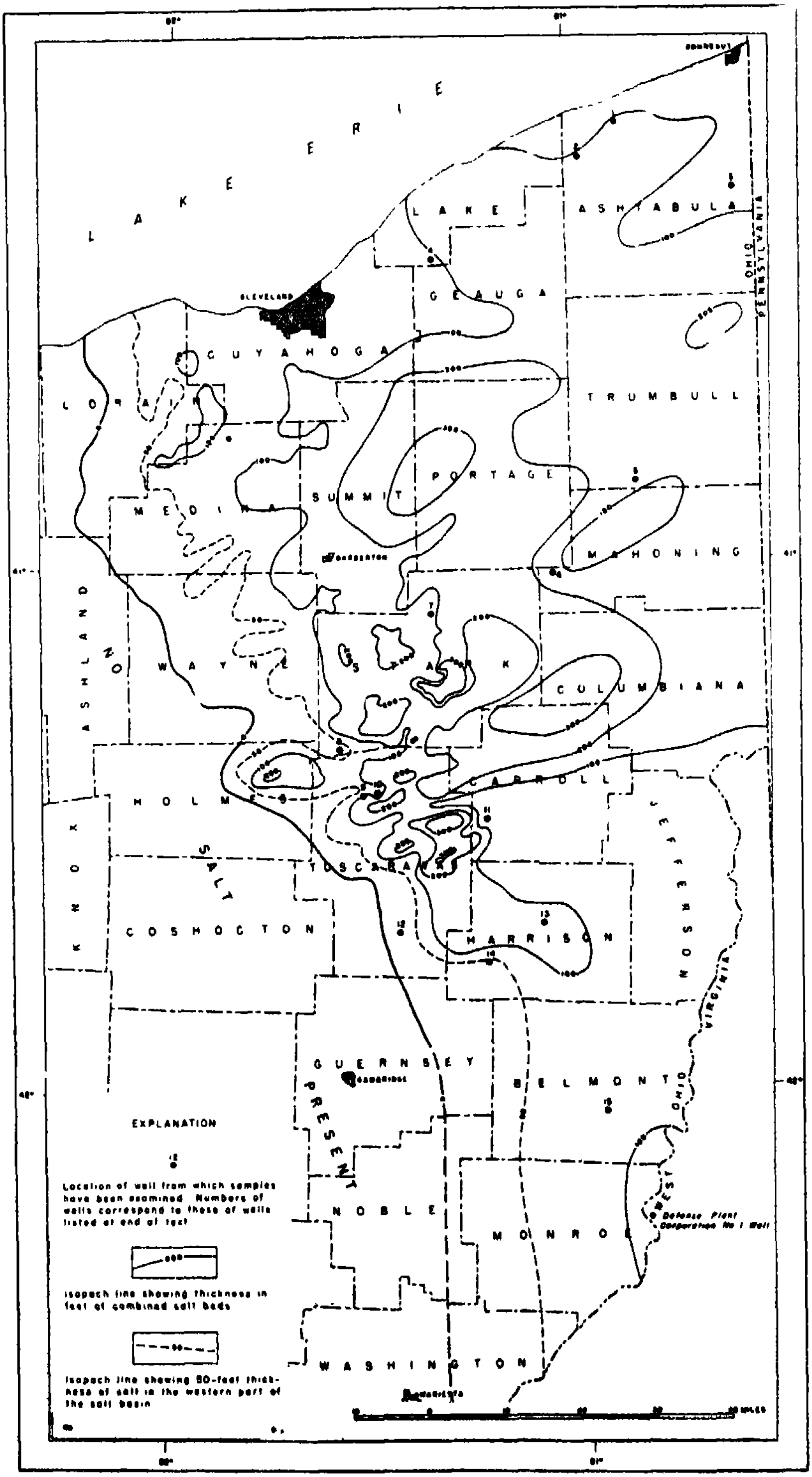
LAKE ERIE
CLEVELAND
LAKE
ASHTABULA
GEAUGA
CUYAHOGA
LORAIN
TRUMBULL
PORTAGE
SUMMIT
MEDINA
MAHONING
OHIO
PENNSYLVANIA
BARBERTON
ASHLAND
WAYNE
STARK
COLUMBIANA
HOLMES
CARROLL
JEFFERSON
KNOX
SALT
TUSCARAWAS
COSHOCTON
HARRISON
GUERNSEY
CAMBRIDGE
BELMONT
PRESENT
NOBLE
MONROE
WASHINGTON
MARIETTA
WEST VIRGINIA
OHIO
Defense Plant Corporation No 1 Well
EXPLANATION
Location of well from which samples have been examined. Numbers of wells correspond to those of wells listed at end of text
Isopach line showing thickness in feet of combined salt beds
Isopach line showing 50-feet thickness of salt in the western part of the salt basin

FIGURE 1. Salt thickness map. Shows the combined thickness of all known beds of salt within the Ohio salt basin.

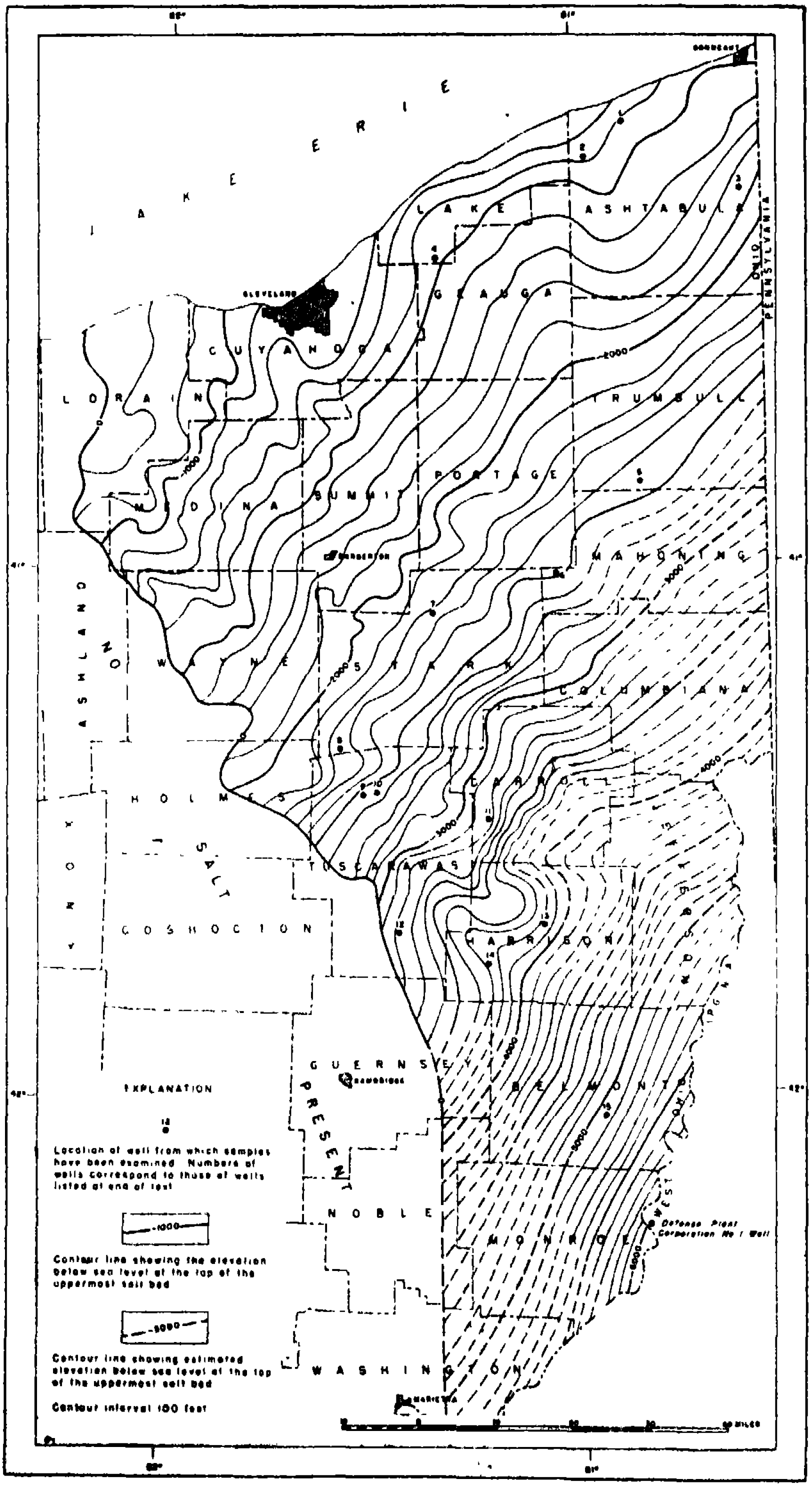
LAKE ERIE
CLEVELAND
CONNEAUT
LAKE
ASHTABULA
GEAUGA
CUYAHOGA
LORAIN
TRUMBULL
PORTAGE
SUMMIT
MEDINA
MAHONING
WAYNE
STARK
COLUMBIANA
ASHLAND
CARROLL
HOLMES
TUSCARAWAS
KNOX
COSHOCTON
HARRISON
JEFFERSON
GUERNSEY
BELMONT
NOBLE
MONROE
WASHINGTON
MARIETTA
OHIO
PENNSYLVANIA
WEST VIRGINIA
SALT
PRESENT
-1000
-2000
-3000
-4000
-5000
-6000
Defense Plant Corporation No 1 Well
82°
81°
41°
40°
MILES
EXPLANATION
Location of well from which samples have been examined Numbers of wells correspond to those of wells listed at end of text
-1000
Contour line showing the elevation below sea level at the top of the uppermost salt bed
-5000
Contour line showing estimated elevation below sea level at the top of the uppermost salt bed
Contour interval 100 feet

FIGURE 2 Map of eastern Ohio showing depth of the uppermost salt bed below sea level.

In the northwestern part of the salt basin, especially in Medina and Wayne Counties, the many well records show a gradual but irregular thinning of the salt beds from east to west. For example, in eastern Medina County the records show a total thickness of 100 feet or more of salt, but near the zero line the salt beds thin to between 5 and 20 feet. Possibly if sufficient sample logs were available, the zero line would show more irregularities, for probably the thin salt beds were deposited in embayments or shallow salt pans along the edge of the salt basin.

THICKNESS AND NUMBER OF THE SALT BEDS

The thicknesses of all known beds of salt within the salt basin have been combined on the thickness map (fig. 1). In the western part of the area shown on the map, in western Lorain and western Medina Counties, the driller usually records a single bed of salt; in Cuyahoga, eastern Medina, eastern Lorain, Summit, Portage, Geauga, Stark, and Tuscarawas Counties from two to four beds are recorded in many wells. The recording of but one thick salt bed in any but the westernmost of these counties is questionable, for probably in many of the wells shaly dolomite or anhydrite is interbedded with the salt. In Ashtabula, Lake, Trumbull, and Mahoning Counties, drillers record from two to five beds; in one well in Trumbull County eight beds of salt were recorded.

Whether the salt in the western part of the basin was deposited as a single bed which splits into several beds eastward is not determinable. Locally a bed may split, but for the most part the salt probably occurs as lenses deposited at different times and hence now lies at different levels within the salt section. For example, in western Portage and western Columbiana Counties an eastward thinning occurs in the rocks lying between the lowest recorded salt bed and the "Newburg," a brine-filled zone of porous dolomite which lies below the salt series and about 200 feet above the base of the Big Lime. The thinning of these rocks suggests that the salt beds to the east are older than salt beds to the west whose vertical distance to the "Newburg" is greater.

DEPTH TO TOP OF THE UPPERMOST SALT

The map (fig. 2) shows by means of contour lines the approximate elevations, below sea level, of the top of the salt within the salt-bearing area. The map is not strictly a structure map, for the top of the uppermost salt encountered in any well may not be at the same stratigraphic level as the top of the uppermost salt in wells in other areas. The difference in stratigraphic level between the top of the salt beds in widely separated wells may be as much as 100 feet. Locally, however, the top of the salt between adjacent wells in any area is probably accurate within half of a contour interval.

The shallowest depth at which salt may be obtained appears to be in an area in Lorain County that includes Sheffield and Avon Townships. There the depth from the surface to the top of the uppermost salt bed ranges from 1,275 to 1,350 feet. From this place the salt beds dip southeastward, about 30 feet per mile, to Barberton, in Norton Township, Summit County, where in the test well of the Columbia Chemical Division of the Pittsburgh Plate Glass Company, the uppermost salt bed lies 2,751 feet below the surface[6] or 1,706 feet below sea level. Fifty-four miles southeast of Barberton the Texas Company's E. A. Mizer No. 1 well in Stock Township, Harrison County, found the uppermost salt at 4,767 feet below the surface or 3,846 feet below sea level. Although wells drilled below the salt are uncommon in southeastern Ohio, the few available records show that the salt dips southeasterly between Barberton and the Ohio River at a fairly uniform rate of about 50 feet per mile, for Martens[7] records the top of the salt at 6,724 feet below the surface or 6,035 feet below sea level in the Defense Plant Corporation's No. 1 well in Franklin district, Marshall County, West Virginia.

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[6] Stauffer, C. R. The geological section at the limestone mine, Barberton, Ohio: Am. Jour. Sci., vol. 242, p. 259, May, 1944.

THICKNESS OF BEDS BETWEEN TOP OF BIG LIME AND TOP OF UPPERMOST SALT BED

According to Martens[8] the interval between the top of the Onondaga (Big Lime) and the top of the uppermost salt bed is apparently highly variable in Pennsylvania and West Virginia, and the irregularity of this interval is particularly noticeable in western Pennsylvania. Cross sections also show variations in the vertical distance between the top of the Onondaga limestone and the top of the uppermost salt bed in Ohio, but the variations apparently are not as great as in Pennsylvania. The greatest vertical distances between the top of the Big Lime and the top of the uppermost salt bed in Ohio are in Columbiana and Portage Counties; these distances decrease markedly to the west and to the northeast.

Lamborn[9] has shown that the Big Lime sequence in Ohio is thickest in a belt along the eastern edge of the State, for he notes: "The thinnest part of the Big Lime as recorded in well records is found in Scioto and Pike counties where it measures about 300 feet. It thickens rapidly to the east and northeast, however, for it reaches its maximum development in Ohio along the eastern edge of the state from Columbiana County south to Washington County. From central Columbiana County this series thins again to the north in the direction of Conneaut. The greatest thicknesses yet recorded in this state are 1,987 feet in the Reamer well located in West Township, Columbiana County, and 1,841 feet in the Knowlton well in Independence Township, Washington County." He further states that "the thickening of the Big Lime to the east is believed to occur chiefly in its middle portion."

A thickening of the Onondaga limestone at the top of the Big Lime sequence has been noted by E. E. Rehn.[10] The thickest belt of Onondaga limestone, as shown on his map, coincides with the thick Big Lime belt shown by Lamborn in Columbiana County.

Further evidence of a thickening of that part of the Big Lime that overlies the salt was noted by the present writer in cross sections and in the records of numerous wells in northeastern Ohio. This evidence is contingent on the assumption that the uppermost salt beds are of equivalent age over a wide area. If isolated beds of salt were deposited somewhat higher in the section than the average for other beds, there would be an apparent thinning of that part of the Big Lime above the salt. As an aid in testing this inference a map of the thickness of that part of the Big Lime above the salt series was constructed (fig. 3). The map brings out several striking features. Most noteworthy is the area of thick limestone trending slightly west of north from Columbiana County through Portage and Geauga Counties to Lake Erie. This belt approximates very closely the belt shown by Lamborn[11] in his thickness map of the Big Limestone sequence. East of the belt of thick lime the lime thins toward the Pennsylvania State line, and west of the belt the lime thins to a narrow area which extends from central Wayne County N. 25° W. across Medina County and into Lorain County. This area is enclosed by the 500-foot thickness contour on figure 3. West of the area enclosed by the 500-foot contour the Devonian limestone and Bass Island dolomite increase in thickness to the western limit of the salt area. The interesting coincidence of the axis of the Parkersburg-Lorain syncline and the western edge of the thin area of Devonian limestone and Bass Island dolomite may be fortuitous or may indicate that the apparent westward thickening of the limestone is caused by the filling of a basin which was downwarped after the salt was deposited. If this basin was present and a proportionately greater amount of limestone was deposited above the salt, then the thickness of the Big Lime which includes the limestones and dolomite above and the dolomites below the salt would be greater than the thickness of the Big Lime east of the basin. This is not true, however, for the

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[7] Martens, J. H. C. Rock salt deposits of West Virginia: West Virginia Geol. Survey Bull. 7, p. 15, 1943.

[8] Martens, J. H. C., idem, pp. 6–9.

[9] Lamborn, R. E., op. cit., pp. 353–355.

[10] Rehn, E. E. Onondaga group of parts of West Virginia and Virginia. Unpublished thesis, Ohio State University, 1942.

[11] Lamborn, R. E., op. cit., p. 354.

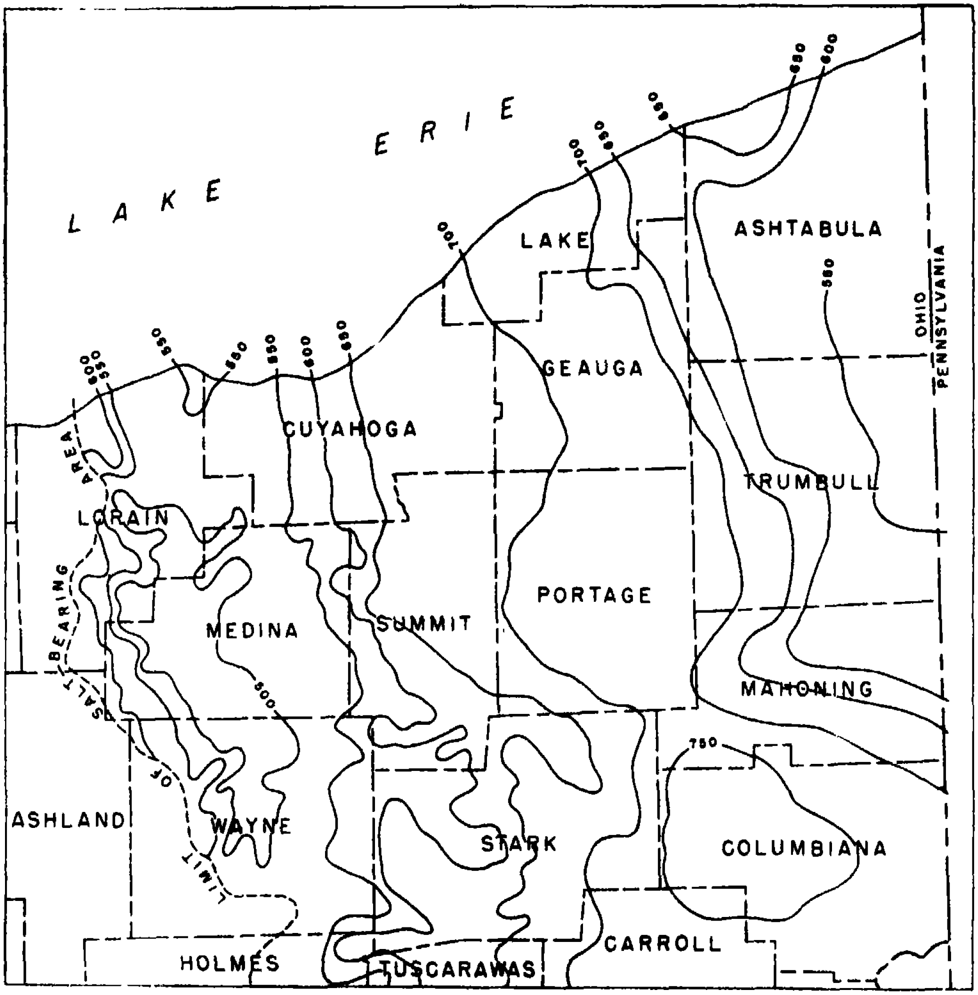

FIGURE 3. Map showing the variation in thickness of the rocks between the top of the Big Lime and the top of the uppermost salt bed. Contour interval 50 feet.

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[13]Lamborn, R. E., op. cit., p. 354.

total thickness of the Big Lime is nearly the same as that shown on the thickness map by Lamborn,[13] which shows a gradual thickening of the Big Lime eastward. The thickening of the Devonian limestone and Bass Island dolomite above the salt may have been caused by subsequent erosion of the upper part of the salt section prior to the deposition of the Bass Island dolomite. Possibly, however, the apparent thickening is caused by the deposition of a salt bed low in the salt section and an absence of deposition of salt beds above at a later time.

When the thickness map of the upper Big Lime is compared with the thickness map of the combined salt beds, the areas of greatest thickness of each nearly coincide in Portage and Columbiana Counties. This relationship would seem to be reasonable proof that the deepest basin of deposition for the salt was likewise the deepest basin of deposition for the limestones above. The uppermost salt bed extends over a broad area and was deposited on an essentially flat surface.

THE LOCATION OF SALT PLANTS

The location of a salt plant depends largely upon the needs of the operator, who may desire a location near other chemical plants or along railroads that have the shortest haul to his markets. If the salt is not obtained by mining but is brought up as a brine from drilled wells, an adequate source of water is essential. Other factors permitting, the operator may desire the shallowest subsurface point in which he may obtain a maximum thickness of salt with a minimum of drilling.

A favorable area for prospecting for salt at a shallow depth lies in Lorain County. This area probably contains a sufficient thickness of salt in one bed to justify the cost of prospecting. If more than one bed of salt is required, then the areas of greatest salt thickness lying in Portage, Stark, and Tuscarawas Counties should be considered. Before a plant site is established and funds are expended for equipment and buildings, it would be prudent to make adequate core-drill tests of the salt series.

DESCRIPTION OF WELL SAMPLES BY R. E. LAMBORN

In the following records Lamborn has estimated the thickness of the salt beds from data derived from an examination of well cuttings. The writer made independent estimates of salt thicknesses from Lamborn's sample descriptions, and these estimates were in very close agreement with his. This agreement, however, may be a coincidence, for the determination of the thickness of a salt bed from well samples is at best an approximation. The thickness of a single salt bed was determined from an estimation of the percentage of salt fragments to other rock fragments in a sample taken at known depths, together with an estimation of the amount of salt taken into solution in the water used in drilling. Other factors considered were the size of the hole, the amount of water used in drilling, and the probable temperature of the water at the depth at which the sample was taken. Any of the factors used in determining the thickness of a salt bed from well cuttings may vary, and other and undeterminable factors may affect the calculations. For example, cavings from other formations, which may include higher salt beds, may change the percentage of salt to rock fragments in the sample, or the water used in drilling may be partly saturated by contact with salt from a bed higher in the hole. The estimated thicknesses of the salt beds have been added to the sample logs only as a possible aid to further prospecting. Samples taken by drill cores through the salt series will provide the only accurate means of determining the thickness of individual beds.

DESCRIPTIONS OF SAMPLES EXAMINED BY R. E. LAMBORN FROM SELECTED WELLS DRILLED THROUGH THE SALT

1. Ashtabula County Saybrook Township Lot 36
J. Q. Metcalf No. 1 By Ohio Oil Company
Elevation 651 feet Total depth 2930 feet Completed in 1941
Located in Ashtabula quadrangle, 0.10 mile N. of 41° 50′ and 2.18 miles E. of 80° 55′

Depth (in feet) to			*Estimated thickness of salt*
Top	*Bottom*	*Description of sample*	*(feet)*
1370		Big Lime	
2052	2060	Rock salt, white	8
2060	2078	Rock salt, brownish	18
2078	2087	Dolomite, brown to gray, argillaceous	
2087	2096	Rock salt, brown	9
2096	2221	Dolomite, gray to bluish-gray, argillaceous, and dolomitic shales; some anhydrite	
2221	2234	Salt	13
2234	2255	Salt	21
2255	2268	20% salt; 80% shale	6
2268	2279	50% salt; 50% shale	8
2279	2288	Salt, nearly pure	9
2288	2304	Dolomitic shale and argillaceous dolomite with a few salt crystals	9
2304	2311	Shale, dark, and argillaceous dolomite; a few salt crystals	4
		Total	105

REMARKS: No salt observed in samples below depth of 2311 feet.

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2. Ashtabula County Harpersfield Township Lot 43
Breyley Bros. No. 1 By Magnolia Petroleum Co.
Elevation 820 feet Total depth 3341 feet Completed in 1940
Located in Ashtabula quadrangle, 1.20 miles N. of 41° 45′ and 1.75 miles E. of 81° 00′

Depth (in feet) to			*Estimated thickness of salt*
Top	*Bottom*	*Description of sample*	*(feet)*
		Big Lime	
2200	2212	Dolomite, dark brown, impure, and dolomitic shale, trace of anhydrite	
2212	2230	Dolomite, dark brown, impure; a few percent of anhydrite and rock salt	9
2230	2250	Dolomite, brown; 25% salt and anhydrite	10
2250	2280	Rock salt, white	30
2280	2315	Dolomite, impure, and dolomitic shale; trace of anhydrite	
2315	2333	Dolomite, buff, porous, impure	
2362	2375	Dolomite, buff, porous, impure, and dolomitic shale	
2375	2385	Dolomite, brown, impure, and dolomitic shale; 30% rock salt	6
2385	2400	Dolomite, buff to brown, impure, a little anhydrite	
2400	2415	Same as above with 10% rock salt	9
2415	2464	Shale, brown to bluish-gray, dolomitic; trace of anhydrite	
2464	2477	Shale, greenish-gray, dolomitic, trace of brown impure dolomite and anhydrite	
2477	2552	Shale, greenish-gray and brown impure dolomite; trace of anhydrite	
2552	2569	Shale, light greenish-gray	
2569	2578	No sample	
2578	2600	Rock salt; a few fragments of dolomite	22
2600	2610	Rock salt	10
2610	2630	Dolomite, brown, dense; 5% anhydrite and rock salt	9
		Total	105

REMARKS: No salt observed in samples from greater depths in this well.

3. Ashtabula County — Richmond Township — Lot 15
Hatton Brothers No. 1 — By Ohio Oil Company
Elevation 1049 feet — Total depth 3841 feet — Completed in 1941
Located in Andover quadrangle, 3.55 miles S. of 41° 45′ and 3.74 miles W. of 80° 55′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
2235		Big Lime	
2905	2928	Chiefly rock salt; a little dolomite	21
2928	2980	Shale, soft, bluish-gray, dolomitic, with anhydrite	
2980	3000	Limestone, light bluish-gray, dolomitic; no anhydrite	
3000	3049	Dark, bluish-gray, impure gypsiferous rock	
3049	3057	Dark-gray impure gypsiferous rock mass, caked by salt	3
3057	3135	Bluish-gray, gypsiferous rock with 5% to 10% rock salt	39
3135	3155	Dark bluish-gray, gypsiferous rock with a few salt crystals	5
		Total	68

REMARKS: No salt observed in samples at greater depths.

4. Lake County — Kirtland Township — Lot 90
F. O. Andrews No. 1 — By East Ohio Gas Company
Elevation 1090 feet (topographic map) — Total depth 3756 feet — Completed in 1940
Located in Mentor quadrangle, 0.25 mile S. of 41° 35′ and 1.00 mile W. of 81° 20′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
1791		Big Lime	
*2523	2549	Dolomite, brown, impure, argillaceous, with anhydrite; 5% rock salt	13
2549	2561	Dolomite, brown, impure, with a small amount of anhydrite	
2561	2576	Rock salt	15
2576	2586	Dolomite, brown, impure; some anhydrite and rock salt	5
2586	2594	Dolomite, light-brown, impure, porous; with anhydrite	
2594	2602	Dolomite, light-brown, impure, porous; some crusting of salt	3
2602	2612	Dolomite, brown; 75% salt crystals	9
2612	2642	Dolomite, brown; 50% salt crystals	21
2642	2788	Dolomite, brown, argillaceous, with anhydrite	
2788	2797	Dolomite, brown, impure, argillaceous; 15% salt; some anhydrite	5
2797	2811	Dolomite, brown, impure, argillaceous; some anhydrite; 30% salt	7
2811	2855	Dolomite, brownish, argillaceous; some greenish-gray shale	
2855	2947	Same, with anhydrite	
2947	2960	Dolomite, brown, impure; 2% salt crystals	8
2960	2969	Dolomite, brown, impure; some salt and anhydrite	5
		Total	91

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*Top of uppermost salt bed recorded by driller at 2534 feet.

5. Trumbull County — Lordstown Township — Lot 20
John Giovannone No. 1 — Magnolia Petroleum Company
Elevation 960 feet (topographic map) — Total depth 4824 feet — Completed in 1941
Located in Warren quadrangle, 1.0 mile S. of 41° 10′ and 0.40 mile W. of 80° 50′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
2785		Big Lime	
3407	3422	Dolomite, dark bluish-gray and brown, argillaceous and gypsiferous, caked by salt	6
3422	3462	Dolomite, brown, impure, with some salt crystals	18
3462	3477	Dolomite, light-brown, impure, argillaceous, with anhydrite	
3477	3503	Same as above, with salt crystals	10
3503	3600	Dolomite, brown, argillaceous, much anhydrite	
3600	3612	Dolomite, brown, impure, porous, with anhydrite	

3612	3640	Dolomite, brown, porous, impure, with some salt	13
3640	3808	Dolomite, brown, dense, impure, argillaceous; with anhydrite	
3808	3838	Dolomite, brown, argillaceous, porous; with anhydrite	
3838	3862	Dolomite, with rock salt and anhydrite	14
		Total	61

Remarks: No salt observed at greater depths.

6. Mahoning County — Smith Township — Section 4
T. S. Schrum No. 1 — By Magnolia Petroleum Company
Elevation 1064 feet — Total depth 5021 feet — Completed in 1941
Located in Alliance quadrangle, 1.7 miles S. of 41° 00′ and 2.78 miles W. of 81° 00′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
2824		Big Lime	
3555	3570	Dolomite, impure; 85% salt crystals	13
3570	3607	Salt crystals	37
3607	3632	Dolomite, buff, argillaceous, with anhydrite	
3632	3680	Dolomite, buff, argillaceous; 5% rock salt	20
3680	3780	Dolomite, buff, argillaceous; trace of anhydrite	
3780	3815	Dolomite, buff, argillaceous; 10% salt crusts	10
3815	3820	Dolomite, buff to gray-black; trace of anhydrite	
3820	3835	No sample	
3835	3881	Dolomite, buff, argillaceous; 70% salt crusts	18
3881	3945	Dolomite, buff, dense, argillaceous; trace of anhydrite	
3945	3983	Dolomite, deep-buff and brown; argillaceous; 5% to 10% salt	15
3983	4044	Dolomite, dark-gray to buff, dense texture, argillaceous; trace of anhydrite	
4044	4062	Dolomite, gray to buff, argillaceous, 5% salt crusts	7
		Total	120

Remarks: No salt observed at greater depths.

7. Stark County — Lake Township — Section 34
Jacob Hyler et al No. 1 — C. W. White
Elevation 1150 feet — Total depth 4584 feet — Completed in 1939
Located in Canton quadrangle, 0.80 mile S. of 40° 55′, and 1.35 miles W. of 81° 20′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
2765		Big Lime	
3372	3382	Dolomite, brown, dense, with anhydrite	
3382	3391	Dolomite, brown, dense, with anhydrite; some salt crystals	5
3391	3402	Dolomite, buff, dense, 5% anhydrite	
3402	3413	Dolomite, buff, dense, 5% anhydrite, a little rock salt	5
3413	3436	Dolomite, buff, dense, with anhydrite	
3436	3448	Dolomite, buff, dense, with anhydrite; 50% rock salt	8
3448	3484	Rock salt, almost pure	36
3484	3495	Dolomite, buff, dense, with 50% anhydrite	
3495	3505	20% anhydrite and dolomite; 80% rock salt	10
3505	3515	Dolomite 50%; rock salt 50%	7
3515	3535	Dolomite, buff, 50%; some anhydrite and shale	
3550	3568	Dolomite, brown, dense, a little anhydrite and salt	9
3568	3578	Dolomite 50%; anhydrite and salt 50%	6
3578	3589	Dolomite 60%; anhydrite and salt 40%	6
3589	3600	Dolomite, buff; a little anhydrite and dark shaly dolomite	
3600	3690	Dolomite, buff, dense, small amount of anhydrite	
3600	3756	No salt recognized	
3690	3756	Dolomite, buff, impure, porous; trace of anhydrite	
3756	3766	Dolomite, buff, porous; some anhydrite, salt, and shale	4
3766	3778	Same as above, 50% salt and shale	5
3778	3790	Chiefly rock salt	12
		Total	113

Remarks: No salt observed in samples at greater depth from this well.

8. Stark County — Sugar Creek Township — Section 34
M. Kaylor No. 1 — By Ohio Oil Company
Elevation 1005 feet — Total depth 4368 feet — Completed in 1943
Located in Navarre quadrangle, 1.55 miles S. of 40° 40′ and 0.85 mile W. of 81° 35′

Depth (in feet) to			*Estimated thickness of salt (feet)*
Top	*Bottom*	*Description of sample*	
2637		Big Lime	
3207	3264	Dolomite, buff, argillaceous; some anhydrite	
3264	3280	Dolomite, buff, argillaceous; some anhydrite; a few salt crystals	9
3280	3304	Rock salt	24
		Total	33

Remarks: No salt recognized at greater depths in this well.

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9. Tuscarawas County — Franklin Township — Section 9
George Smith No. 1 — By Columbian Carbon Company
Elevation 935.6 feet — Total depth 4477 feet — Completed in 1941
Located in Navarre quadrangle, 1.45 miles S. of 40° 35′ and 2.10 miles W. of 81° 30′

Depth (in feet) to			*Estimated thickness of salt (feet)*
Top	*Bottom*	*Description of sample*	
2859		Big Lime	
3498	3532	Rock salt 85%; 15% brown, impure dolomite	32
3532	3600	Dolomite, buff and brown, impure; with some shale; trace of anhydrite	
3600	3658	75% salt; 25% brown, impure dolomitic rock	49
3658	3666	Dolomite, buff, impure; trace of anhydrite	
3666	3675	Dolomite, buff to brown, porous; trace of anhydrite	
3675	3700	50% rock salt; 50% buff, impure dolomite and gypsiferous shale	17
		Total	98

Remarks: No salt recognized at greater depths.

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10. Tuscarawas County — Dover Township — Lot 30
Robinson Clay Products Co. No. 3 — By Brendel Producing Company
Elevation 900 feet (topographic map) — Total depth 4623 feet — Completed in 1940
Located in Navarre quadrangle, 1.15 miles S. of 40° 35′ and 0.20 mile W. of 81° 30′

Depth (in feet) to			*Estimated thickness of salt (feet)*
Top	*Bottom*	*Description of sample*	
2863		Big Lime	
3482	3490	Dolomite, buff, dense, with rock salt	5
3490	3502	Same as above; 60% rock salt	9
3502	3514	Dolomite, buff; some anhydrite with rock salt	5
3514	3529	Dolomite, buff; a little anhydrite	
3529	3545	Same as above; much rock salt	5
3545	3554	Dolomite, buff; porous, trace of anhydrite	
3554	3566	Dolomite, buff to brown, shaly; trace of anhydrite	
3566	3608	Dolomite, dark brown, dense texture; trace of anhydrite	
3608	3623	Chiefly rock salt; a little brown dolomite and anhydrite	15
3623	3638	Chiefly rock salt; a little brown dolomite and anhydrite	15
		Total	54

Remarks: No salt recognized at lower levels in this well.

11. Carroll County — Monroe Township — Section 9
S. W. Tipton et al No. 1 — By Brendel Producing Company
Elevation 948 feet — Total depth 5496 feet — Completed in 1941
Located in Carrollton quadrangle, 4.55 miles S. of 40° 35′ and 3.4 miles W. of 81° 10′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
3540		Big Lime	
4130	4140	Rock salt, nearly pure	10
4140	4200	Dolomite, gray to dark-drab, argillaceous	
4200	4230	Same as above with 10% salt crusts	11
4230	4285	Dolomite, deep-buff to light-brown, dense, argillaceous	
4285	4290	Same as above, with 5% salt crusts	2
4290	4400	Dolomite, gray to dark-brown, dense, argillaceous	
4400	4405	No sample	
4405	4420	Dolomite, gray to dark-brown, dense, argillaceous; 20% salt cake	7
4420	4460	Dolomite, buff, dense, argillaceous	
4460	4470	Same as above; 5% salt cake	3
4470	4490	Dolomite, brown to buff, dense, argillaceous	
4490	4520	Same as above; with 50% salt crystals	22
4520	4540	Dolomite, brown, argillaceous; trace of salt	
		Total	55

REMARKS: No salt recognized at greater depths in this well.

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12. Tuscarawas County — Clay Township — Section 22
Benjamin J. Carrothers No 1 — By Ohio Fuel Gas Company
Elevation 1144.9 feet — Total depth 5289 feet — Completed in 1936
Located in Uhrichsville quadrangle, 1.92 miles S. of 40° 20′ and 2.58 miles W. of 81° 25′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
3504		Big Lime	
4375	4390	Dolomite, brown; a little anhydrite; 20% rock salt.	12
4390	4401	Same as above, small amount of rock salt.	5
		Total	17

REMARKS: No salt recognized at lower levels in this well.

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13. Harrison County — Stock Township — Section 32
E. A. Mizer No. 1 — By The Texas Company
Elevation 926 feet — Total depth 6301 feet — Completed in 1945
Located in Scio quadrangle, 1.40 miles S. of 40° 20′ and 0.75 mile W. of 81° 05′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
4121		Big Lime	
4764	4802	Rock salt; 5% brown impure dolomite	35
4802	4826	Rock salt	24
4826	4859	Dolomite, gray to brown, argillaceous, with anhydrite	
4859	4894	Dolomite, buff to dark-brown, argillaceous, with salt cake	13
4894	4907	Dolomite, gray to gray-brown, dense, argillaceous, trace of anhydrite	
4907	4940	Dolomite, gray to brown, dense, argillaceous, some anhydrite; a few salt crystals	14
4940	4967	Same as above	11
4967	5002	Same as above	14
5002	5121	Dolomite, brown, dense, argillaceous, parts shaly; trace of anhydrite	

5121	5145	Rock salt, white; 3% impure dolomite	24
5145	5172	Rock salt 60%; 40% argillaceous dolomite	22
5172	5194	Shale, soft, brown; with anhydrite	
5194	5221	Dolomite, brown, argillaceous, trace of anhydrite	
5221	5276	Dolomite, brown, argillaceous, shaly; a few salt crystals; trace of anhydrite	26
5276	5287	Dolomite, brown; argillaceous, shaly; trace of anhydrite	
5287	5304	Dolomite, gray to light-buff, argillaceous; a few salt crystals	8
		Total	191

Remarks: No salt recognized at greater depths in this well.

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14. Harrison County — Washington Township — Section 2
W. H. Blackwell No. 1 — By Ohio Oil Company
Elevation 1135 feet — Total depth 6255 feet — Completed in 1941
Located in Flushing quadrangle, 1.10 miles S. of 40° 15′ and 0.65 mile E. of 81° 15′

Depth (in feet) to *Top*	*Bottom*	*Description of sample*	*Estimated thickness of salt (feet)*
4230		Big Lime	
4836	4856	Salt, gray to buff; small percent of dolomite	20
4856	4865	Rock salt, nearly pure	9
		Total	29

Remarks: No salt recognized at greater depths in this well; no salt recognized in samples above depth 4836.

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15. Belmont County — Smith Township — Section 19
T. H. Mobley — Natural Gas Company of West Virginia
Elevation 1174 feet — Total depth 7887 feet — Completed in 1940
Located in Clarington quadrangle, 3.35 miles S. of 40° 00′ and 2.50 miles W. of 80° 55′

Depth (in feet) to *Top*	*Bottom*	*Description of sample*	*Estimated thickness of salt (feet)*
5451		Big Lime	
6231	6254	Dolomite, dark-bluish, impure; sample encrusted with salt	7
6254	6313	Same as above with larger percent of rock salt	23
6313	6345	Dolomite, brown, impure, with a trace of salt	13
6345	6464	Dolomite, dark-brown, impure, and dolomitic shale; much anhydrite	
6464	6625	Dolomite, buff, impure, and dark dolomitic shale; much anhydrite	
6625	6647	Dolomite, dark brown, impure; some anhydrite; salt encrusted	7
6647	6655	Dolomite, light brown; dark brown dolomitic shale; some anhydrite	
6655	6662	Same as above; caked with salt	
6662	6687	Dolomitic shale, brown, gypsiferous, with some salt	10
6687	6695	Same, salt encrusted	3
6695	6701	Shales, buff, with anhydrite and some salt crusts	
6701	6809	Dolomite, buff, impure, and dolomitic shale; somewhat encrusted with salt	2
		Total	65

CHARACEAE OF THE PUT-IN-BAY REGION OF LAKE ERIE (OHIO)[1]

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During the summer of 1940, while a student at the Franz Theodore Stone Laboratory of the Ohio State University, the writer made a series of collections of the Characeae from the Put-in-Bay region of Lake Erie. Further collections were made during brief visits in 1941, at which time the entire shore line of the bay was dredged with "Nordstedt hooks"[3] in an attempt to rediscover several species previously reported by Pieters (1901). The determinations of the collections were recorded in a Master's Degree Thesis at Northwestern University (Wood, 1942). In 1946, the writer was able to compare his material with the original Pieters collections and with additional specimens in the New York Botanical Garden, and to review his original determinations in light of what had been learned through personal association with G. O. Allen of England.

The objective of the present paper is to present as workable a treatment as practicable to enable students of the Biological Station to determine the Characeae of the region. To attain this objective, the classical arrangement for such a work has been somewhat forfeited in the following ways: (1) the key which attempts to contrast differences in apparently similar species regardless of taxonomic relationships; and (2) the illustrations which, having been prepared in chart form with structures of similar species placed together and reproduced at the same magnification, enable ease in comparing and contrasting critical characters with a plant in hand. The terminology has, as far as possible, been stated in non-technical words with the technical terms inserted parenthetically.

The nomenclature, for the convenience of the student, follows that of T. F. Allen's *Characeae of America*, Part II (1892, '94, '96) for the Nitellas, and Robinson's *The Chareae of North America* (1906) for the Charas. This has been done because these works are the most usually available studies of the American forms. Deviations from this nomenclature, as indicated in recent monographic works, are noted in the discussion of each species.

Although the objective has aimed at clarification and simplification for student use, every attempt has been made to bring the fundamental data in accord with the most recent trends in the taxonomic literature of the Characeae.

THE REGION

The Put-in-Bay region is delimited in this study to an area including South Bass, Middle Bass, North Bass, and their adjacent islands, Catawba Point, and inland to the Blue Hole of Castalia. For a discussion of the region, the reader is referred to Tiffany (1937, p. 912).

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[1] Financial aid for the publication of the plates was granted from the Research Fund of the Ohio Academy of Science.

[2] The writer wishes to acknowledge with deepest sincerity the inspiration and aid of C. E. Taft of the Ohio State University in suggesting this problem. The gracious cooperation of F. J. Seaver and Rosalie Weikert, of the New York Botanical Garden, who made the vast collections of that institution available for study, was invaluable. He is deeply indebted to G. O. Allen, well-known English authority on Charophyta, for the hospitality, patience, and instruction during the writer's visits in the war years. The author especially acknowledges the encouragement and guidance of his adviser, L. H. Tiffany, of Northwestern University.

[3] Allen, T. F. Bot. Gaz. 12: 297, 1887.

COLLECTIONS AND LITERATURE

Apparently the only work on the Characeae of this region was published by Pieters (1901) in his *Plants of Western Lake Erie*, based on his collections in the area in 1898. The material was determined by T. F. Allen and Otto Nordstedt. In this study were reported 14 species, 1 variety, and 10 forms; and photographs of three species and two forms were included. Pieters' collection was deposited in the Cryptogamic Herbarium of the New York Botanical Garden (NY).[4] For over forty years no further publications on the Characeae of the region appeared.

The writer's collection of 1940 and 1941 was prepared in duplicate. A set was left at the Stone Laboratory, representative specimens of all species were deposited in the Cryptogamic Herbarium of the Chicago Natural History Museum (F), and the remaining specimens were retained in the writer's herbarium (RDW).

NOTES ON TERMINOLOGY

The terms stem, branches, leaves, rays, dactyls, leaflets, bracts, spines, stipulodes, and heads are employed because of their general usage in the taxonomic literature. They are in part useful in that they suggest similar structures in flowering plants. The *stem* refers to the primary vertical axis. *Branch* refers to the one or two vertical axes which arise in the center of a whorl of leaves. *Leaf* refers to one of the laterals in a whorl at a stem or branch node. *Ray* refers to one of the segments of a furcated leaf in Nitellas. *Dactyl* refers to one of the set of rays beyond the last furcation of a leaf in Nitellas. *Leaflet* refers to one-celled processes arising at the sterile modes of leaves. *Bract* refers to one-celled processes arising at the base of the sex organs. *Spine* refers to the one-celled processes arising along the stem from the cortical nodes in Charas. *Stipulode* refers to the one-celled processes forming one or two rings about the stem at the base of the leaves in Chara. *Head* refers to occasional dense semi-globular clusters of short leaves which occur on certain Nitellas and are characteristic of Tolypellas. In modern literature (Groves and Bullock-Webster, 1920, 1924; Zaneveld, 1940), the term branchlet replaces our usage of leaf, bract replaces leaflet, and bracteole replaces our term bract.

The sex organs have been long known in the literature as antheridia and oogonia. The name *antheridium* is applied to the spherical sex organ in which the spermatozoids originate. In the light of recent morphological concepts (Goebel, 1930), this term is a misnomer; the term antheridium is restricted in use to the individual spermatogenic cells of the capitular filaments within the spherical structure. Smith (1938, p. 131) employs the noncommittal and more descriptive term, globule. The name *oogonium* is applied to the female sex organ which is encased by spirally twisted enveloping cells and terminated by a coronula of five (*Chara*) or ten (*Nitella, Tolypella*) terminal cells at the abaxial end. Smith employs the equally noncommittal word, nucule, for this structure. Both globule and nucule have occurred in the literature from time to time; and as the antheridia and oogonia, as taxonomically employed, are in themselves misleading, Smith's usage is to be recommended. Numerous other authors have attempted to establish more morphologically consistent terms such as antheridiocarp and oogoniocarp, antheridium and sporangium, antheridium and sporocarp. However, to be consistent with the majority of the literature, the writer has retained *antheridium* and *oogonium* in the present work.

NOTES ON TECHNIQUE

A study of the Characeae will be greatly facilitated by good plant material in fertile condition. In our region the best collecting is done in June and July before silt deposition and epiphytes cover the specimens, and while most of the species are fertile. However, certain types of treatment will render most specimens determinable. Charas with heavy lime incrustation can be treated with dilute nitric or hydrochloric acid to remove the carbonate. If objectionable bubbles remain in the tissues, the plants can be boiled for a moment, or placed in water and subjected to suction from an aspirator pump until cleared. Specimens covered with silt deposition or epiphytes can generally be cleaned by cautious wiping of critical structures to be studied.

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[4] Abbreviations for herbaria as used in locality records for each species follow Lanjouw (1939), with the exception of the herbaria of R. B. Gordon (RBG) and the author (RDW).

For study collections, it is advisable to prepare both dry herbarium mounts for permanent record and preserve specimens in 4% formalin or some other algal preservative. For herbarium mounts, the plants are best floated out in a pan so as to assume a natural appearance. Mounting paper can then be slid under the specimen and the material cautiously lifted from the water so as not to disarrange the plant. The material can be covered with cloth, and dried between blotters. The cloth can then be carefully peeled off, leaving the plant attached to the paper. The writer routinely puts the wet specimens between folded newspaper instead of using cloths. Certain charas will not stick to the mounting paper, and in such cases a weak solution of mucilage can be used in place of water for floating out the specimens. If this latter method is employed, the use of cloths is almost required.

Microscopic study of the critical portions is generally essential, though with practice most local forms can be recognized at sight. Sex organs, though not obligatory in all cases, are essential in certain species such as *Chara Haitensis* and *C. compacta.*

In determining Charas the cortical cells along the stem are a major character to be studied. In order to determine the numerical relation between the corticating cells and the leaves in an adjacent leaf whorl, one may actually count the cells across a portion of the stem and the number of leaves in the whorl above or below, and decide whether the cortical cells are one, two, or three times the number of leaves in a whorl. In practice, however, one generally inspects the cortication and locates the primary cells by the presence of spines or nodal cells. Where these primary cells lie side by side, the number of cortical cells will be equal to that of the leaves in a whorl (*haplostichous*; no representatives in our flora, cf. *C. canescens* Lois.). Where a secondary cell lies between two such primary cells, the number of cortical cells will be twice that of the leaves (*diplostichous*, as in *C. contraria*, Plate III, fig. 3-A). Where two secondary cells lie between the primaries, the number of cortical cells will be three times that of the leaves in a whorl (*triplostichous*, as in *C. fragilis*, Plate III, fig. 4-A).

A second taxonomic character somewhat difficult to study is the presence or absence of cortication on the basal leaf internodal cell, especially since the stipulode ring at the base of the leaves may obscure these cells. However, under low power (100 X) one can separate the stipulodes and ascertain whether or not the cortication of the leaves extends completely to the base of the leaf (as in *C. fragilis*, Plate III, fig. 4-A), or whether it is interrupted by a clear portion—the naked base cell (*gymnopodous*, as in *C. Haitensis*, Plate IV, fig. 1-A, where two stipulodes are removed to show this cell). In practice one becomes accustomed to recognizing the apparently vacant space at the base of the leaves as indicating the gymnopodous condition rather than attempting to see the cells themselves. This appearance can often be recognized in the field.

The pattern of the oospore membrane is of diagnostic value especially in species of *Nitella*. This can easily be demonstrated by obtaining a *mature* oospore or oogonium, and crushing it gently under the cover glass on a slide in a drop of water. High dry objective (440 X) is generally adequate to make out the markings on the outer wall. In our species these patterns range from finely granular (*N. gracilis*, Plate I, fig. 2-E) to coarsely reticulate (*N. tenuissima*, Plate I, fig. 3-E).

KEY TO THE PUT-IN-BAY CHARACEAE

The following key should enable the student to determine all the local species in sterile or fertile conditions. The plates, which are arranged in nearly the same order as the key entries, can be conveniently used on questions of terms. In essence, the plates form a pictorial key in themselves, and with little practice will replace rather than supplement the following presentation:

1. Stems smooth, not striated lengthwise (uncorticated)..................(2)
1. Stems striated lengthwise (corticated)..................(9)
  2. Leaves in whorls not forked or divided; spine-like stipulodes encircle the stem at the base of the leaves; antheridia occurring at the base of the oogonia..........(8)
  2. Leaves in whorls usually one or more times divided or forked; without a circle of spine-like stipulodes at the base of the leaves; antheridia, if at the same node as the oogonia, then above or beside it, not at the base of it.................(3)
3. Dense globular clusters of short, fertile leaves forming heads which are borne in center of whorls of elongated sterile leaves..................(4)
3. Without globular heads; leaves similar throughout..................(5)
  4. Heads 3–8 per plant, 2–3 (or more) cm. in diameter; tips of fertile leaves terminated by a series of short cells and a conically pointed tip ...5.[5] *Tolypella intertexta*
  4. Heads 20 or more per plant, up to 8 mm. in diameter; tips of fertile leaves not terminated by a series of short cells, the long dactyls narrowing to a point, 1. *Nitella subglomerata*
5. Tips of leaves narrowing to a point, not terminated by a small apical cell (mucro); fertile leaves clustered in small globular heads about 8 mm. in diameter, 1. *Nitella subglomerata*
5. Tips of leaves terminated by 1 or more minute apical cells; fertile leaves not clustered into heads..................(6)
  6. The small apical cells of the leaves consisting of a single-celled mucronate tip (Plate I, fig. 2-A)..................(7)
  6. At least some of the mucronate tips more than one-celled, varying from a single-celled mucro, to a mucro and a somewhat longer penultimate cell, to a 2–4–cuspidate crown (Plate I, fig. 4-A)..................4. *Nitella megacarpa*
7. Main stem axis not continuous throughout the plant, but branching frequently at nodes resulting in a diffuse type of growth; number of cells in the ultimate divisions of the leaves (dactyls, Plate I, fig. 2-B) varying from 2–3, of which the terminal cell is a small mucronate tip, and the lower 1 or 2 are elongated leaf cells.....2. *Nitella gracilis*
7. Main stem axis generally continuous throughout the plant, rarely appearing branched or diffuse, the whorls of leaves being regularly distributed along the stem; number of cells in the ultimate divisions of the leaves (dactyls) uniformly 2, of which the terminal cell is a small mucronate tip, and the lower an elongated leaf cell, 3. *Nitella tenuissima*
  8. Spine cells (bracts) arising from the base of the oogonia shorter than the oogonia (about one-half length of the mature fruit); leaflets at the sterile leaf nodes reduced to mere papillae, less than 2 times as long as wide, usually obscure, 6. *Chara Braunii*
  8. Spine cells arising from the base of the oogonia as long or longer than the oogonia; leaflets at sterile leaf nodes well developed, generally more than 3 times as long as wide, forming a circle of spines about each node of the leaf...7. *Chara Schweinitzii*
9. Leaves corticated with the exception of 1 or more terminal cells; the basal leaf cell always corticated; stipulodes either obscure or up to 3 times as long as wide, and in 2 rows, an upper and a lower series..................(10)
9. Leaves either corticated or uncorticated, but in either case, the basal leaf cell is always uncorticated. If leaves corticated, the stipulodes more than 5 times as long as wide, and in two rows. If leaves uncorticated, the stipulodes long, but in only one row....(12)
  10. Number of cortications of stem 2 times the number of leaves in an adjacent leaf whorl (diplostichous); stipulodes generally less than 2–3 times as long as wide.. (11)
  10. Number of cortications of stem 3 times the number of leaves in an adjacent leaf whorl (triplostichous); stipulodes obscure or merely papillae....10. *Chara fragilis*

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[5] The numerals preceding the plant names correspond to their numbers in the text.

11. White bulbils generally present on rootlets; spine cells along the stem well developed on the upper internodes; stipulodes well developed, generally 2–4 times as long as wide; stem cortication irregular; antheridia and oogonia occurring on separate plants (dioecious) ..... 9. *Chara Macounii*

11. Without bulbils on rootlets; spine cells generally absent on stems, even on upper stem internodes, or if present, infrequent and very small; stipulodes rarely exceeding 2 times as long as wide, generally blunt; cortication regular; antheridia occurring at the base of oogonia at same leaf node (monoecious) ..... 8. *Chara contraria*[6]

  12. Leaves uncorticated; stipulodes in one row; plants small, up to 10 or 15 cm. high ..... 11. *Chara Keukensis*

  12. Leaves corticated, though the basal leaf internodal cell is always uncorticated; stipulodes in two well-developed rows, an upper and a lower series; plants up to 45 cm. or more high ..... (13)

13. Leaves straight, frequently exceeding 3 cm. in length; leaflets at sterile leaf nodes reduced to mere papillae; antheridia occurring at the base of oogonia[7], 12. *Chara Haitensis*

13. Leaves generally somewhat curved, rarely exceeding 2.5 cm. in length; leaflets at sterile leaf nodes forming a circle of spines about the node, regularly more than twice as long as wide; antheridia and oogonia occurring at different nodes of a leaf, or on different leaves of the same plant ..... 13. *Chara compacta*

Family **Characeae**

Subaquatic cryptograms with numerous chloroplasts per cell. Vegetative parts consisting of long internodal and short nodal cells, forming the stem and leaves. Leaves produced in whorls originating on the stem nodes. Sex organs borne on nodes of leaves. Sexual reproduction by means of biflagellate spiral-shaped antherozoids originating in the spherical male sex organ, and oospores borne in the female organ. Oogonium with envelope of five spirally arranged internodal cells, the apices of which form a coronula of small cells at the abaxial end of the oogonium. Germination gives rise to a protonema from which the plant sprouts as a lateral branch.

Tribe **Nitelleae**

Stems and leaves entirely without cortical cells. Branches similar to the main stem, two or more at a stem node, originating in the axils of the whorls of leaves. Leaves one or more times divided into one-celled rays, excepting the ultimate ray (dactyl) which may be more than one-celled. Cells of the coronula ten, in two superimposed series of five cells each.

Genus **Nitella**

Branches usually two at a stem node, opposite. Leaves one or more times furcate with more or less equal rays. Fertile leaves frequently contracted into heads. Antheridia terminal, in the furcations of the leaves, replacing the apical cell of a ray. Oogonia lateral at the leaf nodes, in monoecious species frequently just below the antheridia. Oospores laterally compressed.

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[6] Certain specimens collected by R. B. Gordon in 1946 have small spines which appear to arise from the furrows in dried specimens; or in which the secondary cortical cells are more prominent than the primaries. These fall within the definition of *Chara vulgaris* L. *pro parte* (cfr. *C. contraria*, in text).

[7] In deciding this character, if any antheridia occur with the oogonia, the plant is *C. Haitensis*. Frequently oogonia occur without the accompanying antheridia. In *C. compacta*, on the other hand, antheridia never occur at the same node as the oogonia. The presence of an isolated antheridium will strongly suggest *C. compacta*, but an isolated oogonium is not significant.

1. **Nitella subglomerata Braun,**[8] Monatsb. K. Akad. Wiss. Berlin, 1858, p. 356, 1858.

Allen, Char. of Amer. II, Fasc. I, p. 7, 1892. Daily, Butler Univ. Bot. Studies, 6: 151, 1944. Woods, Fl. Nebraska, p. 123, 1894.

N. acuminata var. *subglomerata* Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 36, 1883. Allen, Bull. Torrey Bot. Club, 2(3): 9, 1871.

Plate I, Fig. 1

Plant monoecious, varying up to 15 or 20 cm. high; slender and fragile in habit. Leaves 6–8 in a whorl, 3–4 times furcate. Terminal rays of leaves narrowed to an acuminate point, one-celled. Fertile leaves contracted into somewhat globular heads about 8 mm. in diameter. Oogonia and antheridia aggregated. Oospores 260–270 μ long, showing about 6 striations; oospore membrane granular without rounded tubercles. Antheridia 270–360 μ in diameter.

In our flora this species is distinct in that it is the only *Nitella* which has terminal rays beyond the last division of the leaf consisting of only one large cell; i.e., not terminated by a mucronate tip.[9] *Tolypella intertexta* is somewhat similar in appearance since both it and *N. subglomerata* form globular heads. However, the number of such heads in *T. intertexta* is only one or two at a node, and these heads are well over 15 mm. in diameter. The heads of *N. subglomerata*, when present, are very abundant, up to 8 per nodal whorl, and each is about 8 mm. in diameter. Further, the fertile leaves of *T. intertexta* have terminal segments of several cells in contrast to the single-celled dactyls of *N. subglomerata*.

Illustrations: Allen, 1892, unnumbered plate; Woods, 1894, plate XXV.

Localities: Lake Erie—*A. J. Pieters a-25*, 1898 (NY); East Harbor—*A. J. Pieters a-55*, 1898 (NY).

2. **Nitella gracilis** (Smith) Agardh, Syst. Alg., p. 125, 1824.

Allen, Char. of Amer. II, Fasc. III, p. 23, 1896. Halsted, Proc. Bost. Soc. Nat. Hist. 20: 176, 1879. Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 58, 1883.

Chara gracilis Smith, Eng Bot. pl. 2140, 1810.

Plate I, Fig. 2

Plant monoecious, varying up to 20 cm. high; stems very slender. Leaves 5–6 in a whorl, 2–3 times furcate; ultimate rays beyond the last division 2–3–celled, the apical cell being a very short mucronate tip, and the penultimate cell tapering toward the terminal tip. Oogonia and antheridia not aggregate, occurring at each furcation of the leaves. Oospore 250–300 μ long, showing about 6 rather prominent ridges. Oospore membrane finely granular. Antheridia about 300 μ in diameter.

The writer has been unable to verify this record, as the only specimen recorded for this locality was apparently on loan at the time of his visit to the New York Botanical Garden. Pieters (1901) listed this species as "*N. gracilis* Ag. *vel sp. affinis*," so that at best it remains a doubtful record.

Nitella gracilis differs from *N. tenuissima* in its diffuse habit, in its finely granular oospore wall, and by the cells of the dactyls which vary from 2–3 cells.

Illustrations: Allen, 1896, unnumbered plate; Groves and Bullock-Webster, 1920, pl 13; Migula, 1925, p. 214, and 1897, p. 161.

Localities: Upper Sandusky Bay—*A. J. Pieters 64*, 1898 (NY). (Not seen by the writer.)

3. **Nitella tenuissima** (Desv.) Kützing, Phyc. Gener. p. 319, 1843.

Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 62, 1883. Halsted, Proc. Boston Soc. Nat. Hist. 20: 177, 1879. Allen, Char. of Amer. II, Fasc. II, p. 24, 1896.

Chara tenuissima Desvaux, Journ. de Bot. 2: 313, 1809.

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[8] Recent monographers, including Groves (1911, p. 32), Braun (1883, p. 36), Zaneveld (1940, p. 61), cite this species as *N. acuminata* var. *subglomerata* Braun.

[9] *Nitella flexilis* (Sm.) Ag., which should be anticipated in this vicinity, has acute or obtuse instead of acuminate dactyls.

Plate I, Fig. 3

Plant monoecious, varying up to 15 cm. high. Leaves 6–8 in a whorl, 3–4–times divided; ultimate rays beyond the last division invariably 2-celled, the apical cell being a very short mucronate tip, and the penultimate cell an elongated leaf cell not much broader than the base of the apical cell. Oogonia and antheridia at the second and third leaf node (not at first furcation). Oospores 200–250 μ long, showing 7–8 fine, low striations. Oospore membrane strongly reticulate, though at times beaded-reticulate. Antheridia about 175 μ in diameter.

Pieters (1901) reported this species as *N. batrachosperma* from East Harbor. The writer was able to see the specimen, and concurs with Nordstedt's determination that it is identical to *N. tenuissima*.

This species is particularly graceful in its long continuous central axis upon which are borne small, tight whorls of leaves at regular intervals, giving somewhat the appearance of a series of balls distributed along the stem. Its regular straight habit of growth separates it from *N. gracilis*, even in the field. The uniformly 2-celled terminal rays beyond the last leaf division, strongly reticulate oospore membrane, and the absence of sex organs at the first leaf division further distinguish it from *N. gracilis*.

Illustrations: Allen, 1896, unnumbered plate; Groves and Bullock-Webster, 1920, pl. 14; Migula, 1897, p. 176, and 1925, p. 217.

Localities: East Harbor—*A. J. Pieters a-27*, 1898 (NY) as *N. tenuissima*; and *A. J. Pieters a-27½*, 1898 (NY) as *N. batrachosperma*, redet. *N. tenuissima*, *fide* Nordstedt.

4. **Nitella megacarpa**[10] Allen, Char. Amer. Exsicc. No. 3, 1880.

Nitella microcarpa subsp. (*N. megacarpa* Allen), Nordstedt *in* Braun, Abh. k. Akad. Wiss. Berlin, 1882, p. 73, 1883.

Nitella intricata Halsted, Proc. Boston Nat. Hist. Soc. 20: 178, 1879, according to Nordstedt *in* Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 73, 1883.

Nitella polyglochin Braun *sensu latiore*, subsp. *megacarpa*, Allen, *loc. cit.*

Plate I, Fig. 4

Plant monoecious, varying up to about 40 cm. high. Leaves about 6 in a whorl, 4-times divided; ultimate rays (dactyls) in two parts, including the small mucronate tip and the lower, large penultimate cell. The mucronate tips varying from single-celled mucros, to mucros with a penultimate cell, to a 2–4–cuspidate crown (Plate I, fig. 4-A). Oogonia and antheridia occurring at the nodes of the leaves, frequently isolated. Oospores 400–530 μ long, showing about 7 broad, low striations. Oospore membrane of irregularly distributed rounded tubercles, varying into a reticulate pattern, and in many cases coalescing into a continuously beaded or smooth reticulation. Antheridia about 400 μ in diameter.

This plant was reported by Pieters (1901) as *N. polyglochin*, but the specimen is identical to Allen's type of *N. megacarpa*.

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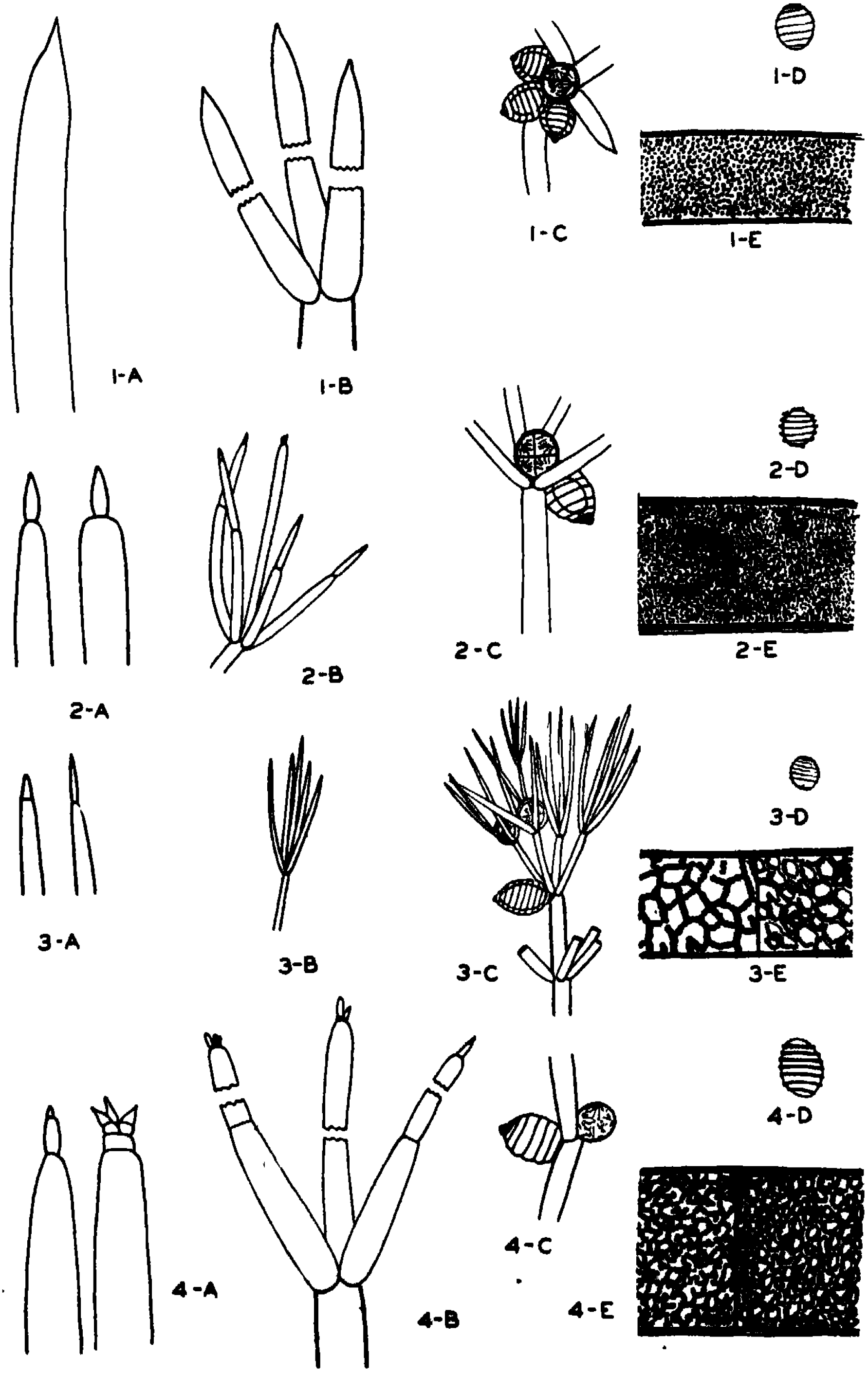
[10] Just what Allen intended to mean by his description: "*N. megacarpa Nov. sp.*—subsp *N. polyglochin* Braun *sensu latiore*," is not clear. This is particularly awkward as Allen (1888, p. 47) made a subgeneric section "brachy-dactylae" as equivalent to "*N. polyglochin* A. Br. in its broadest sense." Based upon this fact, and upon the definite "*Nov. sp.*," the writer has retained *N. megacarpa* in this paper.

Zaneveld (1940, p. 103) includes *N. polyglochin* Braun, *in sensu latiore*, under *N. microcarpa* var. *microglochin* (Braun) Zanev. in a new combination. If this is substantiated, Allen's *N. megacarpa* will be reduced to a form of var. *microglochin*, or included as a synonym.

EXPLANATION OF PLATE I

FIGS. 1–4. In each case *A*. refers to terminal cell of leaf, × 40; *B*. dactyls, × 20; *C*. fruiting leaf, × 20; *D*. oospore, × 20; *E*. a portion of the oospore membrane between two striations, × 220 (in figs. 3-E and 4-E, two phases of pattern shown). Fig. 1. *Nitella subglomerata* Braun (1-A through 1-D after Allen, 1-E after Woods). Fig. 2. *N. gracilis* (Sm.) Ag. (after Groves and Bullock-Webster). Fig. 3. *N. tenuissima* (Desv.) Kütz. (3-A, 3-B, 3-E after Groves and Bullock-Webster; 3-C, 3-D after Migula). Fig. 4. *N. megacarpa* Allen (camera lucida drawings from No. 3, Characeae Americanae Exsiccatae, author's herb.).

PLATE I



In the field, the broad clumps of leaves give somewhat the appearance of a *Myriophyllum* or *Utricularia*.

Illustrations: None.

Exsiccatae: Allen, Char. Amer. Exsicc. No. 3, 1880.

Localities: East Harbor—*A. J. Pieters a-26*, 1898 (NY), as *N. polyglochin*.

Genus **Tolypella**

Branches usually more than two to a stem node. Sterile leaves simple or divided; fertile leaves furcate with very unequal rays, normally forming dense heads. Antheridia and oogonia usually long-stalked. Antheridia solitary, lateral at the nodes of the leaves or at base of leaf whorls. Oogonia always aggregated. Oospores subglobose.

5. **Tolypella intertexta** Allen, Bull. Torrey Bot. Club, 10: 115, pl. 42, 1883.

Plate II, Fig. 1

Plant monoecious, varying up to 50 cm. high. Sterile leaves 8 in a whorl, divided toward the apex into 3 or 4 rays. Fertile leaves densely contracted into heads situated in the vortex of the whorls of sterile leaves, 2- (rarely 3-) times divided. Oogonia aggregated at the fertile leaf nodes. Oospore 450–475 μ long, showing 10 acute striations. Antheridia short-stalked, about 380 μ in diameter, borne laterally at the fertile leaf nodes.

This species is readily distinguished from the Nitellas by the large, dense heads of fertile leaves amid the whorls of long sterile leaves. *N. subglomerata* has somewhat this appearance (cfr. *N. subglomerata*), but this character is not apparent in the field in contrast to the striking "birds-nest" appearance of *T. intertexta*.

Pieters (1901) reported this plant for the region: "Occurs in Hatchery Bay, but the plants are nowhere thrifty." In 1941, the writer dredged the entire shore of Put-in-Bay, which includes Hatchery Bay, in an unsuccessful attempt to recover this species. Pieters stated further: "In some spots an abundance of *Chara contraria* was found with a trace of *C. coronata* and *Tolypella intertexta*, but there are but few Characeae in Put-in-Bay. In the deeper parts of Lake St. Clair, *Tolypella intertexta* covers the bottom with a luxuriant growth, but in Put-in-Bay this species is scarce and the plants are small."

Illustrations: Allen, 1883, pl. 42; 1888, p. 50.

Localities: Hatchery Bay—*A. J. Pieters a-1*, 1898 (NY); in Put-in-Bay, west arm near U. S. F. Commission Hatchery. In about 10–15 feet of water—*A. J. Pieters a-1*, 1898 (NY). Note. Both specimens apparently from same collection, but occur on different sheets with different collection data, but with same number, *a-1*.

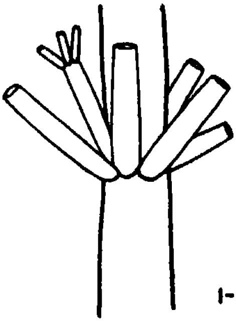
Tribe **Chareae**

Plants with or without lime incrustation. Stem and leaves with or without cortical cells. Branches similar to the main stems, usually one at a stem node in the axil of the oldest leaf. Leaves 6–16 in a whorl at each stem node, not furcate, with one-celled leaflets at the leaf nodes (reduced to mere cells in certain species). Stipulodes at the base of the leaves in a double or single row, or rudimentary. Cells of the coronula in a single row of five cells.

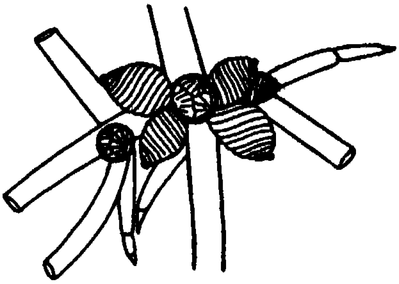
EXPLANATION OF PLATE II

FIGS. 1–3. In each case *A*. refers to stem node, showing stipulodes in figs. 2-3, × 20; *B*. fruiting leaf nodes, × 20; *C*. terminal cells of leaf, × 20; *D*. leaflets at sterile leaf node, × 20. Fig. 1. *Tolypella intertexta* Allen (1-A, camera lucida drawing from *Pieters a-1* (NY), 1-B through 1-D after Allen). Fig. 2. *Chara Braunii* Gmelin (1-A through 1-C after Groves and Bullock-Webster; 1-D camera lucida drawing from *R. D. Wood 106* (F)). Fig. 3. *C. Schweinitzii* Braun (1-A, 1-C after Woods; 1-B after Allen; 1-C camera lucida drawing from *J. Gray 1* (RDW)).

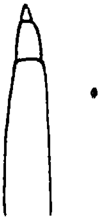
PLATE II



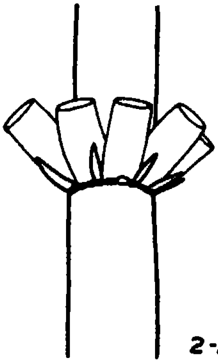
1-A



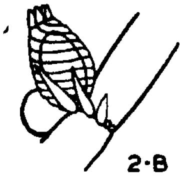
1-B



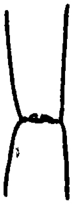
1-C



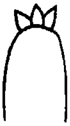
2-A



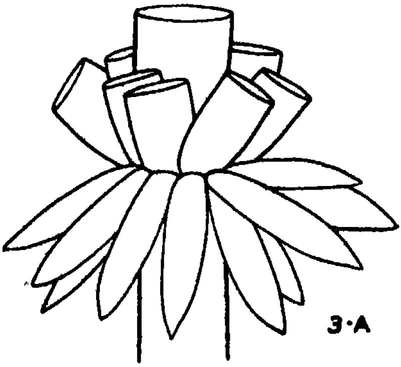
2-B



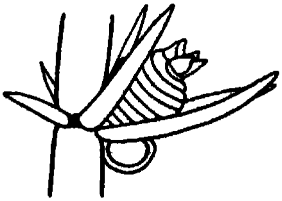
2-D



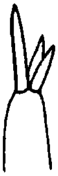
2-C



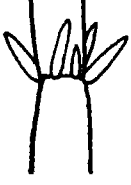
3-A



3-



3-C



3-D

Genus **Chara**

Stems and leaves corticated or uncorticated. Stipulodes always present, sometimes rudimentary. Leaves consisting of 5–14 articulations. Leaflets 5–7, the posterior (abaxial) ones frequently reduced. In monoecious species, antheridia and oogonia either borne at different leaf nodes, or the antheridia at the base of the oogonia.

6. **Chara Braunii**[11] Gmelin, Fl. Bad. 4: 646, 1826.

Robinson, Bull. N. Y. Bot. Gard. 4: 258, 1906.

Chara coronata Ziz. (*ined., c. annum* 1814) Braun, Ann. Sci. Nat, ser. II, 1: 353, 1834.

Allen, Amer. Nat. 16: 358, 1882. Daily, Butler Univ. Bot. Studies, 6: 155, 1944; *ibid.* 7: 129, 1945.

Plate II, Fig. 2

Plant monoecious, varying up to 20 cm. high. Stems and leaves sometimes partly incrusted with lime, totally uncorticated. Leaves 10–12 in a whorl. Stipulodes at the base of the leaves in one series, alternating with the leaves, and generally spreading. Bract cells at the base of the oogonia shorter than the mature oogonia. Leaflets of the sterile leaf nodes rudimentary. Oogonia and antheridia borne together at leaf nodes, antheridia at base of oogonia. Oospore 520–600 μ long, showing 7–9 striations. Antheridia 250–275 μ in diameter.

Allen (1882b) made a detailed study of the American forms of *C. coronata* (= *C. Braunii* Gm.), and concluded that the species was so polymorphic with intergradations that to attempt to describe specific forms was impractical. In collections of plants from the Put-in-Bay region this conclusion is well demonstrated, as forms intergrading between this species and *C. Schweinitzii* occur regularly. Zaneveld (1940), however, reviewed the species critically, and concluded that *C. Braunii* could be separated into six distinct varieties. The *C. Braunii* of the Put-in-Bay region would agree with *C. Braunii* var. *Braunii*, and our *C. Schweinitzii* with *C. Braunii* var. *Schweinitzii*. In both cases, the writer was able only to assign the various local intergrades either to one or the other species as approaching *C. Braunii* or *Schweinitzii*. Certainly, the recent monographic works which unite these forms into one species have taken the step in the right direction.

The fact that this species is absolutely uncorticated throughout frequently results in its being mistaken for a *Nitella*. However, the presence of stipulodes at the base of the leaves immediately separates it from *Nitella* and *Tolypella*. *C. Braunii* differs from *C. Schweinitzii* in having the leaflets at the sterile leaf nodes rudimentary instead of forming a ring of spines, and by the bracts at the base of the oogonia shorter in length than the mature oogonia.

Illustrations: Groves and Bullock-Webster, 1924, pl. 26; Woods, 1894, pl. XXX, fig. 1, 4, labeled *C. coronata;* Migula, 1925, p. 226, and 1897, p. 324, both labeled *C. coronata.*

Localities: Put-in-Bay—*A. J. Pieters a-23*, 1898 (NY) as *C. coronata, microptila, incrustata;* East Harbor—*A. J. Pieters a-41*, 1898 (NY) as *C. coronata;* Carp Pond, East Harbor—*A. J. Pieters a-42*, Aug. 10, 1898 (NY) as *C. coronata;* Just S. W. of Gibralter Laboratory dock along Alligator Bar, 3–5 foot littoral over gravel—*R. D. Wood 106*, Aug. 27, 1941 (F).

7. **Chara Schweinitzii**[12] Braun, Ann. Sci. Nat, ser. II, 1: 353, 1834.

Robinson, Bull. N. Y. Bot. Gard. 4: 249, 1906.

Chara coronata Schweinitzii Braun, Flora 18: 60, 1835.

Chara coronata Ziz. Braun, in part. Daily, Butler Univ. Bot. Studies, 4: 156, 1944.

Chara coronata forma *macrocarpa, meioptila, verticillata, tenuior, leiopyrena* Allen, Amer. Nat. 16: 364, 1882.

Chara coronata forma *macrocarpa, macroptila, verticillata, laxior, leiopyrena* Allen, *ibid.* p. 365.

Chara coronata forma *meiocarpa, microptila, unilateralia, laxior* Allen, *ibid.* p. 366.

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[11] Zaneveld's (1940, p. 141) classification includes our specimen in his combination *Chara Braunii* var. *Braunii* (Braun) Zanev. forma *typica* Zanev. The frequent use of *C. coronata* Braun (1834) must be considered a later homonym of *C. coronata* Bischoff (1828), and both later homonyms of *C. Braunii* Gmelin (1826).

[12] Zaneveld (1940, p. 139) cites this species as *C. Braunii* var. *Schweinitzii* (Braun) Zanev.

Plate II, Fig. 3

Plant monoecious, varying up to 150 cm. high (in our region usually less than 30 cm. high). Stems and leaves sometimes partly incrusted with lime. Leaves 8–11 in a whorl. Leaflets at sterile leaf nodes forming a ring of small spines about each node. Stipulodes at the base of the leaves alternating with the leaves, in one row, and generally spreading. Bract cells at the base of the oogonia 1½–3 times as long as the mature oogonia. Antheridia at the base of the oogonia at the leaf nodes. Oospores 520–650 μ long, showing 9–11 striations. Antheridia 280–320 μ in diameter.

In our region specimens frequently show in the field a banded mottled effect due to incrustation of lime across the leaf node. This is very obvious even when seen from a boat. Many plants form a bushy rather than attenuated growth in quiet, shallow water. It can generally be separated from *C. Braunii* by the ring of leaflets at the sterile leaf nodes, and the bract cells which are 1½–3 times as long as the mature oogonia (cfr. *C. Braunii*).

Illustrations: Allen, 1882b, p 364, fig. 5, and p. 366, fig. 7; Woods, 1894, pl. 30, fig. 2, 5, 6, and 7, labeled *C. coronata*.

Localities: Fisher's Pond—*J. Gray 1*, Aug. 7, 1940 (RDW), *3*, *4* (F); Fisher's Pond—*G. Marguard 5*, Aug., 1940 (RDW); in first embayment west of Erie Isle Dock, South Bass, protected 2 feet of water—*R. D. Wood 109*, Aug. 27, 1941 (F) as *C. contraria*, but includes mostly *C. Schweinitzii;* Shallow water in embayment east of Oak Point in Squaw Harbor, Put-in-Bay—*R. D. Wood 110*, Aug. 27, 1941 (F) as *C. contraria*, but includes mostly *C. Schweinitzii;* East Harbor—*A. J. Pieters a-32*, 1898 (NY) as *C. coronata*, *meiocarpa*, *meioptila;* Squaw Harbor—*A. J. Pieters a-74* (NY) as *C. coronata* f. *incrustata*.

8. **Chara contraria** Braun *ex* Kützing,[13] [14] Phyc. Germ. p. 258, 1845.

Halsted, Proc. Boston Nat. Hist. Soc. 20: 187, 1879. Robinson, Bull. N. Y. Bot. Gard. 4: 265, 1906. Woods, Fl. Nebraska, p. 126, 1894. Daily, Butler Univ. Bot. Studies, 6: 158, 1944; *ibid.* 7: 127, 1945.

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[13] The author citation "Braun *ex* Kützing" apparently has not appeared in the literature. In Kützing's description, the name appears as "*C. contraria* Braun." Our usage thus indicates that Braun did not validly describe the species; but in describing it, Kützing ascribed the new species to Braun (cfr. International Rules, Art. 48 (1935)).

[14] Since the completion of the manuscript, the collections of R. B. Gordon have brought to the attention of the writer certain specimens which show features generally attributed to *C. vulgaris* L. As the intergradations between these aulocanthous forms and typical tylacanthous *C. contraria* seem to make a clear-cut differentiation impossible, the author has decided to include these aberrants in *C. contraria* to which the vast majority of the local specimens clearly fall. An analysis of *C. vulgaris* with the aberrant specimens seen is given herewith.

Chara vulgaris Linnaeus, Spec. Plant., 2: 1156, 1753, *pro parte*.

C. foetida Braun, Ann. Sci. Nat., ser. II, 1: 354, 1834.

Plant monoecious, varying up to 50 cm. or more high. Leaves 7–9 in a whorl, frequently with 2 or more uncorticated terminal cells. Stipulodes at the base of the leaves in two rows, short and blunt, generally well developed. Spine cells on internodes of stem appearing to arise from furrows between the ridges (aulocanthous, a feature especially noticeable in dried specimens), usually mere papillae. Corticating cells of stem twice the number of leaves in an adjacent leaf whorl, quite regular in pattern. The secondary cortical cells more prominent than the primaries. Antheridia at base of oogonia at same node. Oospores golden-brown to dark brown, ellipsoid or ellipsoid-cylindrical, 425–675 μ long, showing 12–15 low striations. Antheridia 325–500 μ in diameter.

This species is separated from *C. contraria* primarily by the aulocanthous cortication in which the secondaries are more prominent than the primaries. In *C. contraria*, the primaries are more prominent than the secondaries (tylacanthous); and in dried specimens the spine cells or cortical nodes appear on the ridges.

Illustrations: Groves and Bullock-Webster, 1924, pl. 28; Migula, 1897, p. 560, and 1925, p. 235.

Localities: Marl Pit, Castalia, Erie County—*R. B. Gordon* 1, Aug. 7, 1946 (RBG); Blue Hole, Castalia, Erie County—*N. B. Green* 4, Aug. 18, 1946 (RBG); *R. B. Gordon* 4, Aug. 18, 1946 (RBG); Miller Blue Hole, Sandusky County—*R. B. Gordon* 6, June 28, 1946 (RBG). (These specimens are also cited under *C. contraria* above.)

Plate III, Fig. 3

Plant monoecious, varying up to 50 cm. or more high. Leaves 6–10 in a whorl, with 2 or more uncorticated terminal cells. Stipulodes at the base of the leaves in two rows, short and blunt, occasionally greatly reduced. Spine cells on internodes of stem usually rudimentary, but occasionally short spines occur on the upper stem internodes. Corticating cells of stem twice the number of leaves in an adjacent leaf whorl (diplostichous), quite regular in pattern. Antheridia at base of oogonia at same node. Oospores black, 600–720 μ long, showing 10–13 striations. Antheridia 300–490 μ in diameter.

Specimens reported by Pieters (1901) as *C. intermedia* from Put-in-Bay do not differ in any apparent aspect from *C. contraria* (cfr. Braun, 1883, p. 153; Robinson, 1906, p. 267).

This species is very similar to *C. fragilis* in appearance, but the latter has triplostichous stem cortication, and the stipulodes at the base of the leaves are rudimentary and obscure. It is very difficult to differentiate *C. contraria* from *C. Macounii* except in good specimens. In the latter species the rootlets generally bear white, starchy bulbils on the rhizoids, the cortical cell pattern is quite irregular with secondary cells overlapping so as to give occasionally a triplostichous appearance, and the plant is dioecious (with rare exceptions with extreme protandry).

Illustrations: Groves and Bullock-Webster, 1924, pl. 23; Migula, 1897, p. 436, and 1925, p. 228.

Localities: Haunk's Pond—*R. D. Wood 13*, Aug. 7, 1940 (F), *14* (RDW); Put-in-Bay—*A. J. Pieters a-71*, July 22, 1898 (NY) as *C. intermedia* A. Br.; protected shoal on Lake Erie shore of gravel just W. of Fisher's pond, Middle Bass, 2 inches of water—*R. D. Wood 104*, Aug 27, 1940 (F); in bayou along east shore of Put-in-Bay on South Bass, just N. E. of Perry Monument, 6 inches of water—*R. D. Wood 105*, Aug. 27, 1941 (F), is a form with nearly naked leaves; Gibralter dock to west along shore—*R. D. Wood 107*, Aug. 27, 1941 (F), a deep water attenuated form; dock at Gibralter, Put-in-Bay, 3 feet of water—*R. D. Wood 108*, Aug. 27, 1941 (F); Blue Hole of Castalia, Erie County—*J. C. Myers 15, 16, 17*, Aug. 9, 1940 (F), and *N. B. Green 4*, Aug. 18, 1946 (RBG), as *C. vulgaris* L.; Miller's Blue Hole, Sandusky County—*R. B. Gordon 6* and *7*, June 28, 1946 (RBG); Marl Pit, Castalia, Erie County—*R. B. Gordon 1*, Aug. 7, 1946 (RBG).

9. **Chara Macounii** (Allen) Robinson, Bull. N. Y. Bot. Gard. 4: 281, 1906.

Chara aspera var. *Macounii* Allen, Bull. Torrey Bot. Club, 9: 44, pl. 21, fig. B, 4–6, 1882

Chara aspera Willdenow, Mag. Ges. naturf. Freunde Berlin, 3: 298, 1809. Daily, Butler Univ. Bot. Studies, 7: 126, 1945, as "Nearest var. *Macounii* Allen or *Chara Macounii* Allen as Robinson, 6, considered it."

Plate III, Fig. 2

Plant dioecious, or very rarely monoecious with antheridia and oogonia on different nodes; varying up to 10 cm. high. Leaves 6–8 in a whorl, corticated throughout except for 1–3 terminal uncorticated cells. Stipulodes at the base of the leaves reduced to ovate or oblong cells, generally pointed, in two rows. Spine cells present on upper stem internodes, but usually reduced to mere papillae Corticating cells of the stem diplostichous, though by overlapping of the secondary cells of the cortical nodes may appear triplostichous for a short distance from that node; tending to be very irregular in pattern. Oospores about 420 μ long, showing about 8–10 striations (?).[15] Antheridia about 620 μ in diameter.

EXPLANATION OF PLATE III

Figs. 1–4. In each case *A*. refers to stem node showing stipulodes at bases of leaves, × 20; *B*. fruiting node of leaf, × 20; *C*. stem cortication, × 20. Fig. 1. *Chara Keukensis* (Allen) Rob. (camera lucida drawings from No. 46, Characeae Americanae Exsiccatae, author's herb.). Fig. 2. *C. Macounii* (Allen) Rob. (2-A and 2-B after Allen; 2-C modified from Allen). Fig. 3. *C. contraria* Braun *ex* Kütz. (3-A camera lucida drawing from *R. D. Wood 14* (RDW); 3-B after Migula; 3-C after Woods). Fig. 4. *C. fragilis* Desv. *ap*. Lois. (4-A and 4-B after Woods; 4-C camera lucida drawing from *R. D. Wood 103* (F)).

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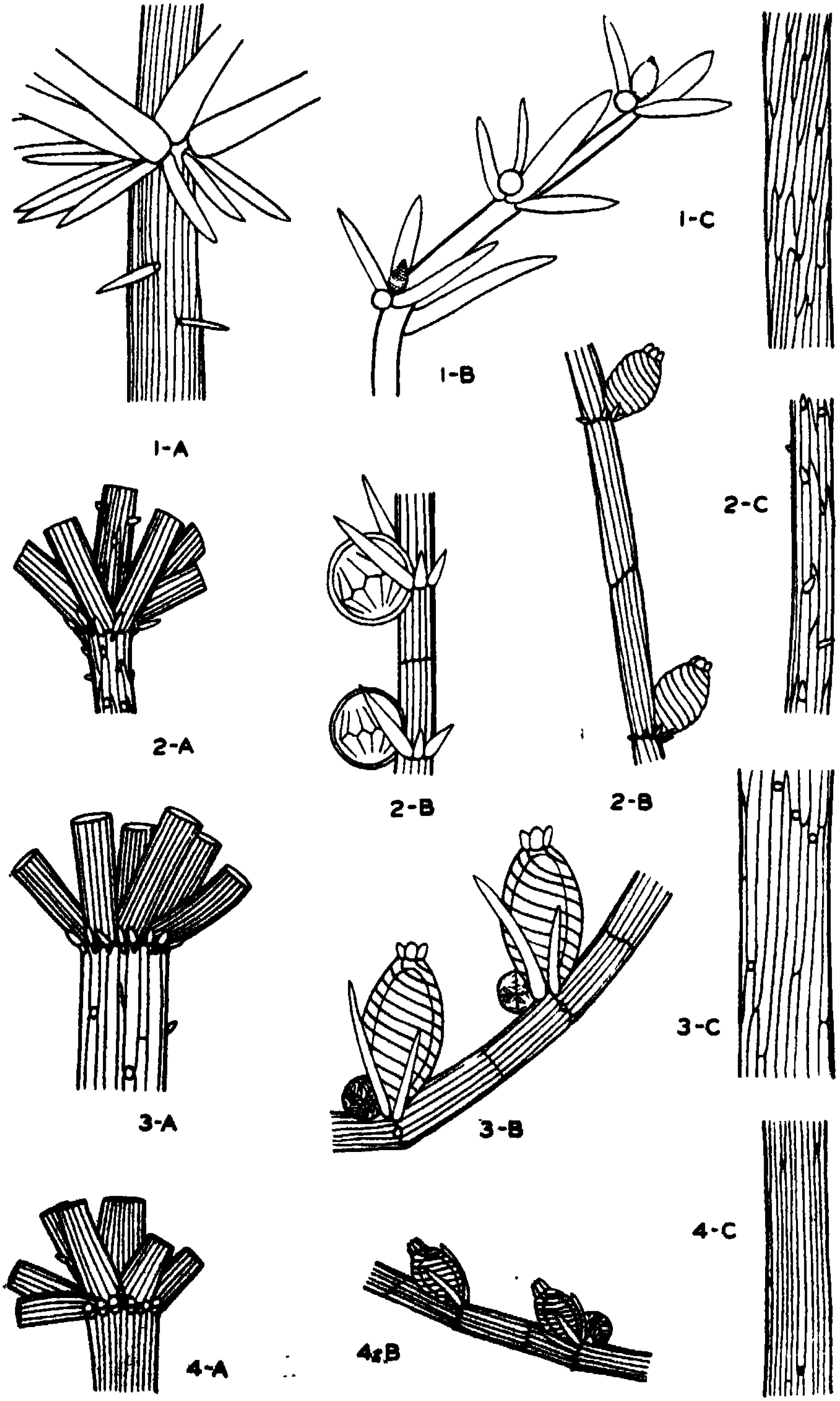
[15] The herbarium material including the type of this species seen by Robinson, Allen, and the author, has all been immature; and exact dimensions of the oospore and number of striae cannot be given with certainty.


1-A
1-B
1-C
2-A
2-B
2-B
2-C
3-A
3-B
3-C
4-A
4-B
4-C

This plant was reported by Pieters (1901) as *C. aspera* Willd., but is represented in his collections at the New York Botanical Garden by a nondescript fragment. It appears to be most similar to *C. Macounii* in all ascertainable respects, but is treated here as a doubtful record.

This species is very difficult to differentiate from certain forms of *C. contraria* (cfr. *C. contraria*) except with excellent material. Certain varieties of *C. fragilis* are very similar, but I have no records of these varieties in the region. All three species form compact tufted bunches in shallow water and assume much the same appearance in this habitat. Similarly, in deep water all three species form attenuated plants. A careful study of the cortication, rhizoids, and sex organs will frequently be essential for final determination (cfr. *C. fragilis*).

Illustrations: Allen, 1882a, pl. 21.

Localities: Squaw Harbor—*A. J. Pieters 67*, 1898 (NY) as *C. aspera* Willd.

10. **Chara fragilis**[16] Desvaux *apud* Loiseleur-Deslongchamps, Not. sur les pl. à aj. à la Fl. France, p. 137, 1810.

Allen, Bull. Torrey Bot. Club, 9: 37, pl. XXII, 1882. Halsted, Proc. Boston Nat. Hist. Soc. 20: 188, 1879. Woods, Fl. Nebraska, p. 127, 1894. Robinson, Bull. N. Y. Bot. Gard. 4: 279, 1906. Daily, Butler Univ. Bot. Studies, 6: 164, 1944; *ibid.* 7: 129, 1945.

Plate III, Fig. 4

Plant monoecious, varying up to 75 cm. high. Leaves 6–9 in a whorl; corticated throughout except for the terminal 1–3 cells. Stipulodes at the base of the leaves rudimentary. Spine cells lacking on stem internodes. Corticating cells of the stem three times the number of leaves in an adjacent leaf whorl (triplostichous), very regular. Antheridia occurring at base of oogonia at same leaf node. Bract cells of oogonia generally exceeding oogonia in length. Oospores black, 550–720 μ long, showing 10–14 striations. Antheridia about 500 μ in diameter.

This species is characteristic in its smooth appearance with very regularly triply corticated stems and leaves, with no spines on the stem, and the stipulodes obscure (cfr. *C. contraria* and *C. Macounii*).

Illustrations: Allen, 1882a, pl. 21; Woods, 1894, pl. 35; Groves and Bullock-Webster, 1924, pl. 63; Migula, 1897, p. 724, and 1925, p. 242.

Localities: East Harbor—*A. J. Pieters a-33*, 1898 (NY) as f. *brevifolia;* Put-in-Bay—*A. J. Pieters a-36*, 1898 (NY) as f. *subinermis;* Haunk's Pond, Middle Bass—*R. B. Gordon 5*, Aug. 17, 1946 (RBG); Wehrle Pond, on false bottom—*R. D. Wood 103*, Aug. 27, 1941 (F); protected shoal on Lake Erie shore of gravel just W. of Fisher's pond, Middle Bass, 2 inches of water—*R. D. Wood 104*, Aug. 27, 1941 (F) as *C. contraria*, but includes fragments of *C. fragilis.*

11. **Chara Keukensis** (Allen) Robinson, Bull. N. Y. Bot. Gard. 4: 273, 1906.

Chara gymnopitys var. *Keukensis* Allen, Bull. Torrey Bot. Club, 20: 120, 1893.

Plate III, Fig. 1

Plant monoecious, 3.5–8 cm. high. Leaves totally uncorticated, mostly 8 in a whorl. Stipulodes at base of leaves in one row, well developed and spreading. Spine cells on stem internodes few. Corticating cells of stem fundamentally twice the number of leaves in an adjacent leaf whorl (diplostichous), because the secondary cortical cells develop well in one direction. These cortical cells may develop for only a short distance in the other direction, giving an incompletely triplostichous condition. Leaflets at sterile leaf nodes developed into large cells equal in

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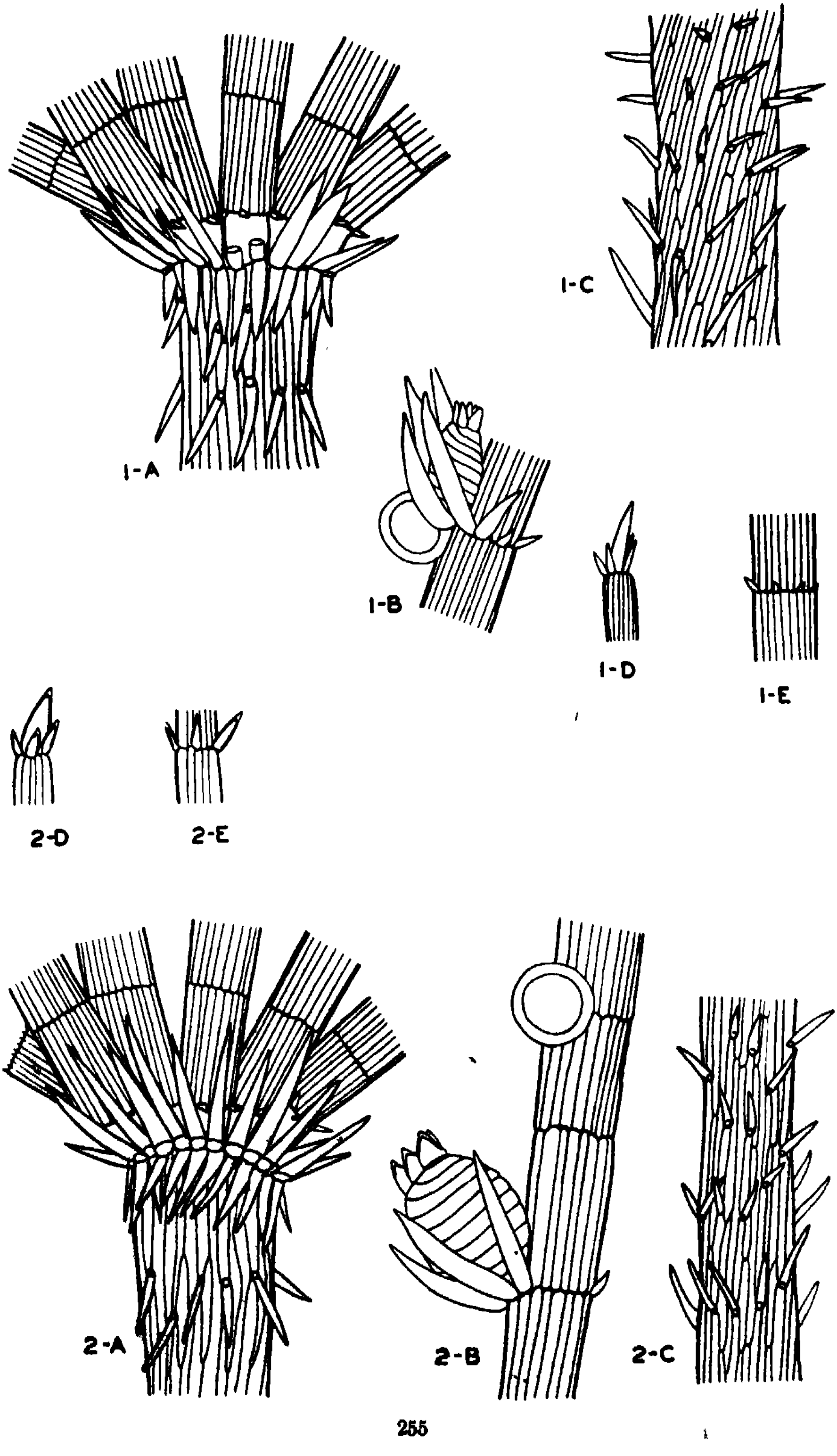
[16] According to G. O. Allen (1940) and Zaneveld (1940) *Chara globularis* Thuillier, Fl. des Env. Paris, ed. 2, p. 472, 1799, is an earlier synonym of this plant.

EXPLANATION OF PLATE IV

FIGS. 1–2. In each case *A.* refers to stem node, × 20 (in fig. 1-A two stipulodes removed to show uncorticated basal leaf internode); *B.* fruiting node of leaf, × 20; *C.* stem cortication, × 20; *D.* terminal cells of leaf, × 20; *E.* leaflets at sterile leaf node, × 20. Fig. 1. ***Chara Haitensis*** Turp. (camera lucida drawings from ***W. MacLain 81*** (RDW)). Fig. 2. ***C. compacta*** Rob. (camera lucida drawings from ***R. D. Wood 41*** (RDW)).


1-A
1-B
1-C
1-D
1-E
2-D
2-E
2-A
2-B
2-C

size to the leaf internodes. Bracts at base of oogonia much longer than oogonia. Antheridia and oogonia generally together at the same leaf node. Oospores 440–490 μ long, showing 9 *somewhat faint striations. Antheridia 250–280 μ in diameter.*

This species is distinct from all other local Characeae by regularly having uncorticated leaves but completely corticated stems. Certain forms of *C. contraria* with only one or two corticated leaf nodes might possibly be confused with it unless careful inspection is made of the whole leaves and cortications.

The plant was reported by Pieters (1901) as *C. Hydropitys forma compacta.* The specimen at the New York Botanical Garden is quite good, and adequate to make the present determination, which concurs with Robinson's written annotation.

Illustrations: None.

Exsiccatae: Allen, Char. Amer. Exsicc. No. 46, 1893; Robinson, *in* Collins, Holden & Setchell, Phyc. Boreali-Amer., Fasc. XXX, No. 1491, 1911.

Localities: Squaw Harbor—*A. J. Pieters 65*, 1898 (NY) as *C. Hydropitys* f. *compacta*, redet. *C. Keukensis* by Robinson.

12. **Chara Haitensis**[17] Turpin, *in* Dict. Sci. Nat. Veg. Acot., vol. 8, pl. at p. 164, 1817.
Robinson, Bull. N. Y. Bot. Gard. 4: 291, 1906.
Chara gymnopus Michauxii Braun, Amer. Jour. Sci. 46: 93, 1844 (*nomen*); Monatsb. K. Akad. Wiss. Berlin, 1858, p. 362, 1858.
Chara gymnopus var. *Michauxii* Braun *in* Allen, Char. of Amer. I, p. 2, 1880.

Plate IV, Fig. 1

Plant monoecious, varying up to 40 cm. high. Leaves 12–16 in a whorl, 3–4 cm. long, corticated except for the apical cell and the basal leaf internodal cell. Stipulodes at the base of leaves well developed, in two rows, the upper longer than the lower. Spine cells few except on the upper internodes. Corticating cells of the stem three times the number of leaves in an adjacent leaf whorl (triplostichous). Spine cells at sterile leaf nodes reduced. Bract cells at the base of oogonia shorter than the mature oogonia. Antheridia occurring at base of oogonia. Oospores 600–900 μ long, showing 13–16 striations. Antheridia about 560 μ in diameter.

From other Charas with corticated leaves, except *C. compacta*, this species is distinct by having the basal leaf internodes invariably uncorticated, and by having two rows of stipulodes at the base of the leaves well over 4 times as long as wide. From *C. compacta* it differs in having the antheridia and oogonia occurring together at the same leaf node, and in its generally much longer leaves which are quite straight instead of curved, giving a brush-like appearance to a leaf whorl. Further, the leaflets at the sterile leaf nodes are nearly obscure in *C. Haitensis;* whereas they form a ring of spines in *C. compacta.*

Illustrations: Turpin, *loc. cit.*

Exsiccatae: Allen, Char. Amer. Exsicc. No. 9, 1880; Robinson *in* Collins, Holden & Setchell, Phyc. Boreali-Amer., Fasc. E, CIV, 1911.

Localities: East Harbor—*A. J. Pieters a-31*, 1898 (NY) as *C. sejuncta;* East Harbor—*W. MacLain 21*, July 10, 1940 (RDW); Portage River—*A. J. Pieters a-53*, 1898 (NY) as *C. gymnopus* var. *Michauxii.*

13. **Chara compacta**[18] Robinson, Bull. N. Y. Bot. Gard. 4: 297, 1906.

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[17] This name appears on an adequate illustration of the plant. No written description of the plant occurs in the text. According to the International Rules, a plate is adequate to establish priority for dates prior to 1908. In this interpretation, Robinson was justified in re-establishing this synonym.

Zaneveld (1940, p. 203) included this species in his new form *C. Zeylanica* forma *typica* Zanev., and transferred it to the earlier homonym *C. Zeylanica* Willd., Mém. Ac. Roy. Berlin, 1803, p. 86, 1805.

[18] This species is given with some reservation. The specimens vary greatly in character of sterile leaf node leaflets; but the size of stipulodes, manner of their not concealing the gymnopodous leaf internodes, number of striations of oospore, and pattern of cortications most closely approach Robinson's type material of this species. Whether this species can be maintained at all is questionable, as the bases of distinction are so relatively minor. Groves (1911, p. 40) includes it under *C. sejuncta* Braun, which the writer feels is probably a more correct disposition.

Chara sejuncta Braun, according to Allen, Bull. Torrey Bot. Club, 21: 526, 1894.

Chara sejuncta forma *compacta*, *subinermis*, *microptila*, *unilateralis*, *macrospora*, *munda* (*nomen*), Allen, Char. Amer. Exsicc. unnumbered specimen (Lake Champlain and Lake Saratoga), 1894.

Plate IV, Fig. 2

Plant monoecious, but antheridia and oogonia occurring at different nodes, frequently on the same leaf; up to 20 cm. high. Leaves 12–14 in a whorl, 1.5–2.2 cm. long; corticated throughout except for the apical cell, and the basal leaf node. Stipulodes at the base of the leaves well developed, the upper row 920–1500 μ long, usually not quite reaching the top of the swollen leaf internodes. Spine cells rather frequent on upper stem internodes. Corticating cells of the stem three times the number of leaves in an adjacent leaf whorl (triplostichous). Leaflets at sterile leaf nodes forming a ring of spines. Bract cells at base of oogonia shorter than the oogonia. Antheridia and oogonia occurring at different nodes, but frequently on the same leaf. Oospores 730–770 μ long, showing 10–12 very conspicuous striations. Antheridia 360–400 μ in diameter.

This species is rather difficult to recognize in the field as distinct from *C. contraria*, *C. fragilis*, and especially *C. Haitensis* (cfr. *C. Haitensis*). However, the effect of the naked basal leaf internodes with the stipulodes gives the living material the appearance of having a very short basal leaf internode, a feature of both *C. Haitensis* and *C. compacta*. But for positive determination of the latter two species, the plants must be inspected microscopically for the leaflet structure, cortical pattern of the stem, number of striations of oospore, and especially the placement of the sex organs.

Illustrations: None.

Exsiccatae: Allen, Char. Amer. Exsicc. *loc. cit.*

Localities: Squaw Harbor—*A. J. Pieters a-37*, Aug. 26, 1898 (NY) as *C. Michauxii;* Haunk's Pond, Middle Bass—*R. D. Wood 41, 43, 45*, Aug. 9, 1940 (F) as *C. sejuncta* f. *compacta; 42, 44* (RDW); *ibid. 21, 22* (RDW) as *C. sejuncta.*

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DDT and the Insect Problem

This is one of the most welcome books to come to the attention of the writer, because it brings together complete up-to-date information about the use of this new and important chemical insect-killer. It is an excellent summary of a great number of scientific facts that have been written concerning the methods and techniques employed in tests for control of the many insects affecting man. Written in a non-technical easy-to-read style, it holds the reader's interest from the opening to the concluding chapter.

The contents by chapters are: Introduction; Insects and Insecticides; Chemistry and Pharmacology of DDT; How to Use DDT; DDT at War; Man's Health and Comfort; Agriculture, Forest, Shade and Fruit Tree Insects.

The sources of the information are given in the list of references at the end of each chapter. Although all the published literature on the subject is not listed, it appears that all the essential reports were reviewed.

This book will be a handy reference for all professional entomologists, as well as the pest control operators and general users of DDT.—*R. H. Davidson.*

DDT and the Insect Problem, by James C. Leary, William I. Fishbein and Lawrence C. Salter. McGraw-Hill Book Company, New York City. 176 pp. 1946. Price $2.50.

OIL IN GERMANY

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The subject "Oil in Germany" was and is of great importance to us because it was and still is a very essential part of Germany's war potential as well as of her peacetime economy.

World War I revealed the importance of oil to military operations. Lord Curzon made the long-remembered statement that the Allies floated to victory on a sea of oil. Marshal Foch added that in war a drop of gasoline is worth a drop of blood.

World War II clearly demonstrated the absolute necessity of oil in war. Not only did the want of it, the need of it, breed the force which attempted to obtain it, but it also played a leading part in the strategy of the victorious side. It is smarter to ground planes and put out of commission tanks by destroying their oil depots than to risk more men and machines by fighting them. Therefore all information concerning the natural and synthetic oil of Germany was classified information and hard to get. Some of the data presented in this study could not be checked or rechecked because of lack of information from the Russian sector of Germany.

First, the geographic location of Germany's natural and synthetic oil, petroleum refineries, oil centers, firms, etc., will be described. Then an oil estimate will be made and finally the elimination of Germany's production of synthetic gasoline and oil will be discussed. It is beyond the scope and time of this study to describe the various processes (Hydronation, Hydrogenation, Carbonization, Bergius, Fischer-Tropsch, Winkler, and other I. G. Farben-processes) used in the production of synthetic oil.

It should be remembered that Germany lacked sufficient natural oil within her own boundaries to maintain her military machine and that even after gaining all the oil in Central Europe, she still lacked enough oil to wage a successful war. This lack was a direct stimulus to the experimentation in snythetics and the production of synthetic oil. Germany built a large number of synthetic plants, all of which were subject to raids during the war. The most important one of these synthetic plants was the Leuna Works at Merseburg. This plant was wrecked by allied bombing, but recently has been restored to 40% of its capacity. It is supplying gasoline to the Russian occupational forces now. Forty percent of the Leuna plant was completely destroyed and about 70% of it was unroofed. Leuna Works is a limited liability corporation whose stock was owned by the I. G. Farbenindustrie A.G. combine. Since Allied confiscation of the German assets of the I. G. Farben-combine, the title to the Leuna Works as well as to many other synthetic oil plants rests with the Allied control council for Germany. At present the plant is employing about 18,000 workers, about half of its wartime peak.

The situation in the other plants listed is similar.

I. NATURAL OIL.—Production of natural oil is centered in North West Germany at:

Nienhagen—Production about 300,000 tons per year.
Rietberg—Production about 300,000 tons per year.
Heide—Production about 50,000 tons per year.

Total production of natural crude oil in Germany for 1942 is estimated at 800,000 tons.

II. PETROLEUM REFINERIES.—Total refining capacity in 1938 was 3,000,000 tons a year. It was centered in the Hamburg area and in the Hanover area.

A secondary concentration was on the Rhine and Ruhr, chiefly at

Emmerich.
Dortmund.
Düsseldorf.

Imports were also refined at Regensburg.

III. SYNTHETIC OIL.—Germany's main source of oil supply. Principal synthetic oil plants:

Location	*Name of Plant*	*Estimated Annual capacity (1,000 Tons p. a.)*
Bergius—Hydrogenation Plants—		
Leuna—Merseburg	Ammoniawerke Merseburg GmbH	400
Pölitz—Stettin	Hydrierwerke AG.	400
Scholven—Buer (Rhur)	Hydrierwerke Scholven Hibernia AG	350
Gelsenkirchen (Rhur)	Gelsenkirchen—Benzin AG	325
Troglitz—Zeitz	Braunkohle—Benzin AG	320
Magdeburg	Braunkohle—Benzin AG	300
Wesseling	Union Rheinische Braunkohlen Kraftstoff AG	250
Böhlen—Rotha	Braunkohle—Benzin AG	200
Lützendorf Mucheln	Wintershall AG	125
Welheim Bottrop (Rhur)	Rhuröl GmbH	100
Blechhammer (Silesia)		
(a) North	IG Farbenindustrie	750
(b) South	IG Farbenindustrie	750
		4,275

Location	*Name of Plant*	*Estimated Annual Capacity (1,000 Tons p. a.)*
Fischer-Tropsch Plants:		
Ruhland—Schwarzheide	Braunkohle—Benzin AG	400
Lützendorf—Mücheln	Wintershall AG	200
Rauxel (Rhur)	Klockner—Wintershall AG	200
Homberg (Ruhr)	Treibstoffabrik Rheinpreussen	200
Holten (Ruhr)	Rhurbenzin AG	130
Wanne—Eickel (Rhur)	Krupp Treibstoffwerke	130
Dortmund (Ruhr)	Hoesch—Benzin GmbH	130
Deschowitz	Schaffgotsch'sche Benzin GmbH	110
Kamen-Dortmund (Ruhr)	Chemische Werke, Essener Steinkohle AG.	50
		1,550

IV. OIL CENTERS.—The following list indicates the storage capacity available at the principal oil storage centers. In each of the town areas it is distributed over a number of individual plants, but in no case is it possible to give even an estimate of the actual quantities which are likely to be in storage.

Place	*Capacity in Tons*
Berlin	68,900
Bremen	748,800
Bremerhaven	459,700
Danzig	5,800
Duisburg	66,500
Düsseldorf	31,800
Emden	43,500
Frankfurt-Main	141,200
Hamburg	1,361,200
Hanover	287,300
Kiel	737,300
Köln	14,000
München	69,000
Rostock	11,000
Stettin	187,000
Stuttgart	17,500
Wilhelmshaven	221,000
	4,471,500

The following underground army oil storage depots are definitely known:

Place	*Capacity in Tons*
Hitzacker (Lüneburger Heide)	2,400,000
This depot consists of 114 "holes" or "departments," each of which contains five storage tanks.	
Farge (14 miles NW of Bremen)	340,000
Nienburg (Lüneburger Heide)	193,200
Loccum (Lüneburger Heide)	15,600
	2,948,800

These figures are by no means complete, but they represent the locations of the principal depots We may assume that the others were destroyed during the war.

V. MAJOR OIL FIRMS.

Firm	*Location*
Bremer Chemische Fabrik A. G	Klaffenbach (Erzgebirge)
I. O. G. Mineralöl-Raffinerie Herzog	München-Ottobrunn
Karl Pohlmann Mineralöl-Raffinerie	Kerbach (Kassel)
Teutonia Mineralöl-Raffinerie	Berlin-Rudow
Alfred Teves	Frankfurt (Main)
Hans R. Schroeter	Magdeburg
Deutsche Hydraulik und Präzisions-werke G.m.b.H.	Berlin-Wittenau
Deutsche Gasolin A. G	Emmerich
Deutsche Vacuum Öl A. G	Oslebshausen
Mitag Deutsche Treibstoffe A. G.	Regensburg
Nerag A. G	Misburg
Rhenania-Ossag Mineralwerke A. G	Königsberg (Pr.)
Shell-Floridsdorfer Mineralölfabrik A. G	Wein-Floridsdorf

The present capacity of these firms is unknown.

VI. OIL ESTIMATE.

It has been estimated that the Germans produce about 267,000 barrels daily now, while our daily production in 1946 was 5,070,000 barrels, plus imports of 370,000 barrels, totally 5,440,000 barrels. There is a tremendous demand for oil in Germany now and Germany has to rely heavily upon petroleum imports from the Middle East and other areas. Germany is forced to convert cars, trucks, etc., to charcoal and similar substitutes. The German nation is very poor in regard to its oil supply. In addition to it the most important oil fields and refineries are dominated by affiliates of the large oil groups, in particular Standard-Vacuum and Shell-group.

VII. GERMANY'S OIL AND THE FUTURE.

Briefly we have surveyed the oil situation as it stands in Germany today. We have seen that production is low principally due to the effects created by World War II. Our bombers destroyed or damaged oil installations from the refineries of Bordeaux to the oil fields of Ploesti. It will be many years before all of these installations are operating on a former capacity basis. On the other hand World War II developed and proved the value of synthetic oil.

In accordance with the Berlin Protocol of March 28, 1946, the Allied Control Council is to determine the amount and character of the industrial capital equipment unnecessary for the German peace economy and therefore available for reparations. All industrial capital equipment for the production of synthetic oil and gasoline is to be eliminated. But 14 lines later the same document states "Facilities for the production of synthetic gasoline and oil, synthetic ammonia and synthetic rubber, and of all ball and taper roller bearings, will be temporarily retained to meet domestic requirements until the necessary imports are available and can be paid for." There is a contradiction between both policies. On one hand we would like to eliminate Germany's war potential and on the other hand we are retaining there the most important war facilities.

We all know that oil is the raw material for a thousand purposes, the source of power in industry, the source of fuel and lubricants and that it must not be kept from or taken away from those who need it. The Atlantic Charter stated that all nations should have the right to trade and access to raw materials of the world whenever necessary to their prosperity. This applies to Germany too.

We also know that Germany will not be able to pay for oil imports for quite some time. Are Standard and Shell willing to accept Christmas toys for oil again as they had to accept them before World War II?

Should we let the Russians have the German facilities for the production of synthetic gasoline and oil? Soon after Anschluss German interests "legally acquired" title to all foreign and domestic oil properties in Austria. This acquisition is at present a cause of considerable concern to the four powers. Under the Potsdam Agreement the Russians were given the right to take German holdings in Austria as reparations. It is the opinion of the writer that such holdings can not properly be considered German, if acquired during the war. A restoration of all property rights to the prewar owners should be attempted. There must not be any transfer of facilities as long as domestic oil requirements are not met.

But at all times there should be a rigid control of all facilities for the production of synthetic gasoline and oil even though converted to civilian production, in order to ensure that these plants are not again used for war purposes. Elimination or transfer of the facilities mentioned do not seem advisable as such acts would cause considerable unemployment in Germany. Reconversion and control seem to be better solutions.

Amiable policy between nations on the subject of German oil cannot bring everlasting peace within itself, but it can be of great assistance, while lack of such an amiable policy can be a great hindrance to peace. All nations seek wealth. Oil is wealth. A proportionate sharing of it is essential to a lasting peace..

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Fleas of Western North America

The study of western fleas has been attractive to the student of descriptive zoology because of the variety and newness of the fauna. Many of the species that have been found were new. Also the presence of plague has made the study of fleas in this area necessary. The classification of fleas is an intriguing subject and this may be illustrated by the fact that the 238 species and subspecies are distributed in 66 genera. Interest has lagged in recent years in the hollow curve of distribution but my guess is that a curve resulting from use of data on fleas would be rather startling.

This book is in three parts dealing with students of fleas, medical significance, field and laboratory technique, and morphology in relation to taxonomy (37 pages); systematic classification and a geographical index of the western fleas and of the eastern fleas compiled from Fox (347 pages); and host indexes (121 pages). This is a bibliography of recent papers, an index to species arranged alphabetically and also according to describer, and a comprehensive general index. An abundance of illustrations, and good materials and printing make this a very attractive book. Its value as an addition to entomological literature is obvious and it will be useful to health officials and sanitary officers, as well as to entomologists.—*C. E. Venard.*

Fleas of Western North America, by C. Andresen Hubbard. 532 pages, illustrated, 6x9, cloth bound. 1947. Iowa State College Press, Ames, Iowa. Price $6.00.

Animal Breeding Plans

The third edition of this well-known book on the principles and practices of animal breeding continues the record of excellence established by the two previous editions. The organization and content are essentially unchanged even though new phrasing and new references occur in many places, adding more than one hundred pages of text. The chapter on Sire Indexes is completely recast.

This book, which has served students of animal breeding for a decade, actually may be used by a much wider public, including students of all phases of genetics. This is due to the fact that the author has clearly and simply described the basic concepts and methods of statistical genetics. A better exposition of the effects of selection and various schemes of inbreeding on the gene frequencies of a population does not exist elsewhere in the literature.—*E. L. Green.*

Animal Breeding Plans, by Jay L. Lush. Third ed. viii 443 pp. 50 figs. Ames, The Collegiate Press. 1945. $3.50.

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ON THE APPLICATION OF CHEMISTRY TO ARCHAEOLOGY

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INTRODUCTION

Archaeology may be defined as the science which yields information and develops theories about past human activity by means of a study of ancient material remains. As a general rule the archaeologist is much more interested in the form or style of such remains than in their chemical composition, for this may often have little or no archaeological significance. For example, the form of flint implements may be an important index to the cultural status of a certain group of early people, but it is improbable that any significant information from the standpoint of archaeology could be obtained from an investigation of the chemical composition of the flint of such implements. But sometimes important archaeological information may be obtained by a study of the chemical composition of material remains. This information may supplement that obtained from a study of form or style, or it may be entirely new information not otherwise obtainable. The purpose of the present paper is to indicate by means of general categories, specific illustrative examples, and a select bibliography how chemical facts, methods, and theories have been and may continue to be applied to the study of the material remains of past human activity for the purpose of furthering archaeological science. Also indicated are miscellaneous ways in which chemistry may be useful to the field and to the museum archaeologist. For the most part the illustrative examples are based upon the writer's own experience, though some mention is made of pertinent work of other investigators.

THE IDENTIFICATION OF MATERIALS

Perhaps the simplest and most obvious application of chemistry to archaeology is the exact qualitative identification of materials in order that these may be accurately described in archaeological publications. The accurate identification of materials is important also because significant interpretations may depend upon the exact nature of certain materials. Errors of identification, some of them rather glaring from the chemical viewpoint, are not infrequent in the older archaeological literature, and are by no means absent from some of the recent literature. Copper is sometimes confused with bronze, bronze with brass, lime mortar with gypsum plaster, solid bitumens with vegetable resins, and so on for other materials superficially similar. Such confusions have arisen either because no proper identification of a material was ever made in the first place or because the archaeologist, even after a correct identification had been made, did not then appreciate the importance of the chemical distinction between certain materials very similar in appearance and put to similar uses. Actually, the inexact or loose identification of the kinds of materials found in excavations may lead to serious error. For example, it might not seem important to determine whether a given object is composed of brass or of bronze, but a very wrong conclusion as to time of manufacture could be reached by a failure to determine which it is, or a failure to appreciate the significance of the distinction, brass having been first made about the middle of the first century B. C. and bronze some twenty centuries earlier.

Though a few materials, such as wood, may be readily recognized, and even identified as to variety, by means of physical appearance alone, it is unsafe as a general rule to rely solely on physical properties for the identification of ancient materials. Even when the material of an object may be recognized by simple inspection, the application of chemical tests may be very desirable both to confirm and to amplify the observation. For example, there is generally no difficulty in recognizing an ancient iron object as such even when it is in the usual highly oxidized condition, but for iron objects of early date it is important to determine whether they were fashioned from meteoric iron or from manufactured iron, the difference in cultural level represented by the use of the one kind as contrasted to the other being very great.

The problem of making a correct identification of ancient materials found in excavations may be very different from the problem of identifying the same materials in a fresh condition. Thus, for example, a clean piece of copper may be differentiated from a clean piece of bronze at a glance because of the difference in color, but no such difference is apparent when the two materials are in a highly oxidized condition, as they usually are when found in excavations. Furthermore, in the identification of materials found in excavations it is not so important to determine what a material is now, as it is to determine what it was originally before it underwent a series of chemical changes. During the excavations at the site of the ancient Agora in Athens, Greece, an object was found in the form of a thin shield. This was described as a bronze shield before a chemical examination was made. Actually no free metal of any kind could be found in it and no compounds of tin could be found among the copper corrosion products. The conclusion was that it was originally a shield of beaten copper. Though the original nature of inorganic materials may usually be determined with little difficulty, it is otherwise with organic materials for these are not only more likely to undergo extensive chemical changes but such changes are generally much more complicated.

For materials that are deceptively similar to each other in appearance chemical tests are of course a necessity for the purpose of differentiation. Silver containing a moderate proportion of alloy cannot with certainty be distinguished from fine silver on the basis of appearance, though such a distinction may be very significant when the objects are in the form of coins. Still more necessary is identification by chemical tests for those materials the appearance of which gives little or no clue as to their actual nature. For example, a white material in the form of lumps and fine powder was found in ornamental ceramic containers in graves of Greek women buried about the fourth century B. C. in Attica. Also found were various other articles of the toilet. After some speculation as to whether the white material was chalk or white clay, chemical analysis showed that it was artificial basic lead carbonate or white lead, evidently used as cosmetic powder.

It is important to note that the exact chemical identification of ancient materials may lead to various inferences and interpretations that are fully as important, or even more important, than the mere establishment of identity for the purpose of correct description. Thus the preceding example of the identification of a material as white lead immediately implies the discovery and use of a process for its manufacture, its sale as an article of commerce, and the employment of a poisonous substance as a cosmetic that may well have had an adverse effect on the public health.

INDICATIONS AS TO SOURCES OF MATERIALS, THE EXISTENCE OF COMMERCE IN PARTICULAR MATERIALS, AND THE DIRECTION OF TRADE ROUTES

The presence of numerous specimens of a material of foreign origin at an archaeological site is a clear indication of the import of such a material through trade or commerce. If the source of this material can also be located then the direction or path of this trade or commerce can be established also. Sometimes the chemical examination of materials can determine whether they are of foreign origin or can supplement other evidence indicating a foreign origin.

Deposits of native copper do not occur in Ohio, yet a large number of artifacts of native copper have been found at various sites in the state. The only possible explanation is that native copper must have been brought into the state, either by trade or in this particular case by expeditions to the source. That the deposits of the Lake Superior region were the source of this copper receives additional confirmation from the fact that the chemical composition of the copper of the artifacts is the same as that of the copper of the Lake Superior deposits.

At the Agora excavations in Athens a number of specimens of a bright red pigment were found which on analysis turned out to be cinnabar, the native sulfide of mercury. The character of the geological formations in Greece do not indicate that cinnabar ever occurred there in appreciable quantities, and therefore it was concluded that in all probability this was an imported pigment. The discovery of ancient cinnabar workings is Asia Minor supports this conclusion and in addition indicates the probable existence of an export trade in cinnabar from Asia Minor to Athens.

True Baltic amber is rather easily differentiated from other fossil resins because it yields a considerable proportion of succinic acid on dry distillation. Objects of fossil resin, identified by this characteristic as Baltic amber, have been found in considerable numbers at prehistoric sites in Greece. In spite of the considerable distance involved, either by the sea route or by travel across the then undeveloped land areas of Europe, the conclusion is that a commerce in amber must have existed between the Baltic coast and the Mediterranean region even in these remote prehistoric times. Indication of the existence of a trade in the reverse direction, at least at a much later period, is given by the composition of small brass objects dating from the opening centuries of the Christian Era which have been found in the eastern Baltic coastal region. There is no evidence that such brass was of native manufacture, and indeed it is improbable that it was in view of the cultural state of the inhabitants of the region at that period. The significant fact is that the brass of these objects was found to have the same composition as the brass of the Roman coins of the same period. From this it has been reasonably concluded that Roman coins reached this distant region by trade and were converted into these objects by the inhabitants.

EXPLANATION OF UNUSUAL PHENOMENA ENCOUNTERED IN THE COURSE OF EXCAVATION

Slow chemical changes extending over long periods of time not infrequently result in unusual phenomena which may lead to erroneous conclusions if not interpreted correctly. For example, an ancient weight found during the excavation of the Agora in Athens appeared to consist of bronze or copper, but a chemical examination showed that it was actually a lead weight coated superficially with a thin plating of metallic copper and with corrosion products of copper. The lead itself was of the usual high degree of purity. From a consideration of the facts it seemed most likely that the thin plating of copper was formed by electrolytic displacement when copper bearing solutions came into contact with the lead object, and that the copper corrosion products were formed by the subsequent corrosion of part of the electrolytically deposited copper. The copper bearing solutions were probably produced through contact of ground water with neighboring bronze or copper objects. In view of the fact that the layer of copper and copper corrosion products on the lead object was still very superficial in spite of burial for approximately 2000 years, it is very probable that the copper bearing solutions were extremely dilute and that as a result the rate of the plating process was exceedingly slow. Similarly, what appear to be bronze or copper examples of well known ancient silver coins have been found which on examination have proved to be actually such silver coins superficially coated with metallic copper and its corrosion products. This type of plating apparently occurred because such coins were simultaneously in contact with copper bearing solutions and an active metal.

Sometimes well-crystallized minerals are found in association with ancient objects, and it may wrongly be concluded that these minerals were originally associated with the objects. The presence of such minerals is more often the result of their formation by natural means near, on, or even in ancient objects after their burial. However, the objects themselves often play a necessary part in the formation of the minerals. For example, the formation of cuprite or azurite on or near bronze objects depends primarily of the material of these objects. Occasionally the association of certain substances with objects occurs because of some very unusual or special condition. For example, a dark brown compound was found in the layers of corrosion products on lead objects from one part of the Agora excavation area. This brown compound was identified as lead dioxide. In view of the fact that this area was adjacent to, and in part actually included, a section of the road bed of an electric railway line it seemed probable that stray electric currents were the essential agency in the formation of the lead dioxide on the lead objects.

DETERMINATION OF THE USES OF OBJECTS

Though the uses to which ancient objects were put is often a matter readily decided by simple inspection, a chemical examination may sometimes be helpful in establishing the exact use to which a given object or a given kind of object was put. This is especially true for containers of various sorts. For example, in the excavations at the Athenian Agora numerous fragments of empty jars were found on the interior surfaces of which was a black or dark brown resinous coating. Since the unglazed pottery body of such jars was porous it was evident that the purpose of the internal resinous coating was to render them impervious to liquid. Impressed stamps on the handles of the jars showed that they were of foreign origin, and it therefore was further evident that they were containers in which some liquid product was imported. Obviously they were not, originally at least, containers used for water. Experiments on the solubility of the resinous coating in various liquids showed that it was more or less readily soluble in vegetable oils. Hence the vessels could not have been used as containers for olive oil or any other vegetable oil. Though soluble to some extent in concentrated alcoholic solutions, the resinous coating was not appreciably soluble in dilute alcoholic solutions containing less then 20% by volume. Therefore it appeared very likely that these jars were containers in which wine was imported. The resinous coating was found to consist of fused mastic resin.

As another example may be cited the results of an examination of the contents of a small jar found in the excavations at Corinth. This was a small round jar of green-glazed pottery with a very narrow neck. It was of Byzantine manufacture and probably of the 12th century A. D. Such vessels have long been classified as pomade jars, but no concrete evidence as to what they originally contained had ever been produced. When found this particular jar appeared to be intact since it was obviously full of something, and its neck was tightly sealed with what appeared to be a corroded iron stopper. However, on opening the vessel it was seen that the rusted mass which filled the neck was simply a part of the remains of an original iron applicator rod that had stood in the vessel and had fitted loosely in the neck. This rod had expanded on rusting and consequently had filled the opening. The vessel itself was found to be filled with fine clay which evidently had infiltrated into the empty or nearly empty jar before the neck had become sealed through rusting and expansion of the iron rod. The hope of finding the jar full of its original contents or the modified remains of these contents therefore met with disappointment. However, the clay from the vessel was extracted with boiling ether and on evaporation of the ether extract there was obtained a considerable quantity of a fatty material that was evidently the remains of the original material left in the vessel before it became filled with clay. This fatty matter was found to consist largely of a mixture of fatty acids which from their properties were judged to be the result of the hydrolysis of the glycerides of a vegetable oil or a mixture of vegetable oils. Evidence obtained by chemical means therefore gave a firm basis to the previous opinion that vessels of this type were used as containers for oils or oily preparations such as might be used for dressing the hair.

DETERMINATION OF THE DETAILS OF ANCIENT TECHNICAL PROCESSES

The scientific examination of ancient objects can yield information about the technique of their manufacture that cannot otherwise be obtained. For example, the microscopic examination of metal objects, coins for example, by the methods of metallography can show whether they were produced by casting or by striking, or by a combination of casting and striking. Likewise the examination of weapons yields interesting details on the method of manufacture. It has been observed, for example, that the edges of bronze or copper weapons were often subjected to severe cold work such as might have been done by long continued hammering, whereas the body of the weapons largely retained their original cast structure. Evidently the hardening effect of cold working was well recognized and deliberately utilized.

Sometimes modern experiments in imitation of ancient processes yield information on the details of the procedures that must have been employed in order to achieve the results now seen in ancient objects. On ceramic bodies and glazes a considerable number of such experiments have been made. It has been found, for example, that the black glaze on certain types of ancient pottery could only have been produced by firing in a reducing atmosphere.

DETERMINATION OF CHRONOLOGICAL SEQUENCES

Chemical methods of investigation are apparently not of general use for the determination of the chronological sequences of ancient objects, though for certain special kinds of objects they may be of considerable use, at least in connection with other kinds of evidence. For example, it was found as a result of quantitative chemical analyses of a large number of ancient Greek bronze coins from different localities that there exists a broad general relationship between the date of production of such coins and their chemical composition. Coins of the earliest date generally contain the highest proportion of tin and very little or no lead. Somewhat later coins contain a lower proportion of tin and a moderate proporation of lead. The latest coins contain the lowest proportion of tin and a very high proportion of lead. Furthermore, a rather sharp change in the composition of these coins was observed to have taken place shortly after the middle of the second century B. C. which may be ascribed to the fall of Carthage and the consequent stoppage in the shipment of tin by the sea route from Britain. This relationship between the chemical composition of the coinage alloy and its date of production has been successfully applied, in connection with other evidence, to the arrangement in chronological sequence of a considerable number of types of the late bronze coins of Athens.

Chemical methods of investigation are sometimes useful for fixing the earliest possible date at which a given object could have been manufactured. For example, it appears to be definitely established on the basis of analyses of numerous dated objects that zinc was not introduced into alloys produced in Mediterranean counries until after the middle of the first century B. C., and therefore the presence of zinc as an essential component in the metal of an undated object from any of these countries is an almost certain indication that this object was not made before this time,

INDICATIONS OF CULTURAL LEVEL AND ECONOMIC CONDITION

The presence or absence of certain kinds of materials may be an index of the cultural status of a people. Obviously the absence of metal among the remains of a given people indicates a low state of technical development and a low state of general culture. The greater the variety of metals and alloys utilized by a people the greater their technical development, and, as a rule, the higher their general cultural development. The same appears to be true for certain kinds of non-metallic materials such as glazes and glasses. Some materials that serve as indices of this nature may, of course, be recognized without chemical aid, though the application of chemical methods may make their recognition more certain. On the other hand, some kinds of materials that are indicative of cultural level are not easily recognized for what they are without chemical aid. For example, the introduction of lead or tin into glazes, or the introduction of certain of the less common elements into glasses, represent technical advances which may be, and in fact sometimes have been, overlooked in the study of ancient remains. An increase in the variety of materials utilized by a people in the course of their existence may be taken as an indication of a rise in cultural development and conversely a decrease may be taken as an indication of a decline.

It is probable that a rise or fall in the variety of materials utilized is also in general an indication of a corresponding rise or fall on economic status, but a more direct indication of this may be obtained through a chemical study of the particular kind of objects that bear a direct relationship to economic status, namely, the coins of a people. For example, the fineness of Roman silver coins underwent a slow but almost steady decrease that paralleled the increasing economic difficulties that occurred with the decline of the empire until finally nothing but silver-coated coins came into use. Sudden changes in the composition of coins may mark sudden economic difficulties or disaster. As illustrative of this an ancient example seems almost inadequate in view of the many striking examples afforded by the numismatic history of Europe in recent years.

EXPLANATION OF THE ALTERATIONS IN THE APPEARANCE OF ANTIQUITIES AS CONDITIONED BY ENVIRONMENT AND TIME

During long burial in the ground a great variety of chemical reactions occur between the material of most objects and the surrounding soil and ground water. In order fully to explain the appearance of objects found in excavations, to deduce with confidence their probable original appearance, or to decide upon the proper method of restoration, it is often essential to understand the nature and course of these chemical reactions. The appearance and general condition of objects of the same material and of the same age taken from different excavation sites may be very different. Thus a simple tin bronze from one site may be coated with a hard coherent layer of corrosion products of the sort commonly called a patina, whereas a similar bronze of the same age from another site may be coated with loose porous masses of corrosion products. The very extent to which objects of a given material undergo corrosion at one site as compared to those at another site may vary enormously. For example, archaeologists observed that bronze found at Corinth was almost invariably in a severely corroded state, whereas similar bronze of equal or greater age found at certain other sites in Greece was not so corroded. A special investigation into this phenomenon showed that the ground water at Corinth happens to contain an abnormally high concentration of chloride, and that this is sufficient to account for the severe corrosion of the buried bronze.

Chemical considerations may also serve to correct common misconceptions as to the original appearance or nature of certain materials or objects. By reason of its usual beautiful iridescent appearance ancient glass, for example, is regarded by some as a product artistically superior to modern glass, and one that cannot be successfully imitated by modern glass makers. Observation has shown, however, that ordinary modern soft glass also becomes iridescent when buried in certain soils, especially those slightly alkaline because of the presence of ammonia from decaying organic matter. Experiments have also shown that this action may be greatly hastened by treatment with alkaline solutions at an elevated temperature. All such action consists in the removal of the metallic ingredients from the surface of the glass leaving thin films of silica on the surface which refract light in spectral colors. If ancient iridescent glass has any real artistic superiority over modern glass made iridescent by chemical treatment it is because the ancient glass has been subjected by natural conditions to a very slow and long continued action which has caused a deeper and perhaps somewhat different type of leaching of the surface.

RESTORATION AND PRESERVATION OF ANTIQUITIES

In general, the deterioration of buried objects is predominantly the result of chemical change, and it is therefore reasonable to expect that the restoration of such objects should be best effected by chemical treatment. The deterioration of bronze or copper, for example, is primarily the result of oxidation, and the reverse process of reduction should tend to restore this to its original condition. This principle has been applied extensively to the restoration of bronze and copper objects. In practice this is done by electrolytic procedures, in one of the best of which the corroded object is made the cathode, an inert electrode of nickel or platinum is used, and the electrolyte is a dilute solution of sodium hydroxide. On passage of a feeble current for a long time, often several weeks, the corrosion products on the object are slowly reduced back to metal, much of which plates back on the object in approximately its original position. At the same time any clay or sand entangled in the corrosion products falls to the bottom of the electrolytic bath. When reduction is complete the object is scrubbed to remove nonadherent matter, thoroughly rinsed with distilled water, and dried in an oven. The results achieved by this means are much superior to those obtained by former methods of mechanical cleaning.

Even when objects are of such nature that they undergo no appreciable chemical deterioration during burial, they may become coated with foreign matter that requires chemical treatment for its safe and effective removal. For example, once there was found an important inscribed Sumerian cone of baked clay that was extensively incrusted with a thick and adherent deposit of calcium carbonate and calcium sulfate which could not be removed mechanically without flaking off the softer inscribed surface of the cone. Treatment with hydrochloric acid readily removed the deposit without damaging the cone. Similarly, incrustations of calcium carbonate on pottery are now often removed on a large scale at excavation sites by treatment with hydrochloric acid.

Whether ancient objects are restored by chemical means or not, problems concerning their preservation for purposes of exhibition or study often arise, and these are frequently best solved by the application of chemical principles. In ordinary air the corrosion of an ancient metal object, for example, may continue at an appreciable rate unless proper precautions are taken. For such an object this problem is sometimes best solved by coating it with a protective layer of wax or synthetic resin. Where such treatment is not desirable or feasible the object may be kept in a sealed glass case containing an inert gas, or in a case containing a powerful desiccating agent that keeps the air very dry. Sometimes special problems arise such as the so-called bronze disease, or cylic corrosion, of bronze or copper objects. Such a problem can only be solved by application of chemical principles.

Occasionally certain problems of this sort not directly connected with ancient objects, yet of interest to the archaeologist, may also be solved by chemical means. The preservation of paper impressions of inscriptions on stone is an example. These paper impressions, which are commonly used in the study of lapidary inscriptions, are obtained by applying one or more large sheets of chemical filter paper over the inscription, thoroughly wetting the paper, pressing it into the carved letters on the stone, letting it dry in place, and then peeling off the dried paper. In this way an exact reverse impression of the inscription is taken. Unfortunately, these convenient copies are fragile and there is a tendency for fine details to be obliterated on frequent handling, or even on storage under humid weather conditions when a number of impressions are piled together. It was found that by spraying such impressions with a special methyl methacrylate lacquer they could be stiffened and toughened to such an extent that these disadvantages connected with their use were completely eliminated.

DETECTION OF FALSE ANTIQUITIES

The forgery or alteration of ancient objects presents a problem that plagues the dealer in antiquities, the museum archaeologist, and sometimes even the field archaeologist. Frequently a counterfeit ancient object may be detected by chemical tests or analyses. As an example may be cited the means by which an alleged ancient Greek bronze statuette, offered for sale to a museum director, was shown to be not as represented. Though satisfactory from the standpoint of style, this object appeared suspicious because of the thinness of the corrosion products or patina on its surface. On analysis of a small sample of the metal taken from an inconspicuous place in the base it was found that this metal lacked the usual impurities such as arsenic, gold, nickel, and silver commonly present in small proportion in genuine ancient bronze. Furthermore, the alloy was found to contain zinc as a major component which failed to agree by at least several centuries with its alleged date. On these bases it was concluded that it very probably was an object of modern manufacture.

Certain physico-chemical methods of examination, either alone or in connection with chemical tests, are useful for detecting forged antiquities and especially for detecting modern additions, alterations, or repairs. Examination under ultraviolet light, for example, is especially useful for the critical examination of ivories and marbles. Under ultraviolet light different marbles fluoresce different colors, and the surface of ancient marble frequently has a characteristic fluorescent color which is very different from that of fresh stone of the same kind. On this basis alterations or repairs in an ancient marble object which are not at all visible in ordinary light may become strikingly conspicuous when the object is viewed under ultraviolet light. Similarly, infrared light and X-rays have been found useful in the detection of falsification.

CONCLUDING REMARKS

The above general categories and the illustrative examples, of which many more could be given, sufficiently show that chemistry may be of important service to archaeology. The titles in the appended bibliography, which is by no means exhaustive, further show the aid that chemistry may render to archaeology. As far as the writer has been able to determine this is the first general bibliography on this special field of investigation. A peculiarity of the published work in this field is its scattered nature and the consequent difficulty of locating and assembling it. Much has been published in obscure periodical works and in the form of pamphlets in small editions. Another considerable proportion has been published in the form of extensive footnotes or appendices in archaeological works. Because of the nature of the subject and the way in which much of it has been published a good many items have escaped the usual scientific abstract journals and general indices. As indicated by the extent of this bibliography much work has already been done in the past. Much more remains to be done, however, and it should be possible eventually to erect a considerable body of special knowledge having its own data, techniques, and general rules. For such a body of special knowledge, a distinct and separate branch of applied chemistry in itself, an appropriate descriptive name would be *archaeological chemistry.*

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FAIRY SHRIMP POPULATIONS OF NORTHEASTERN OHIO IN THE SEASONS OF 1945 AND 1946

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Throughout the late winter and spring of the years 1945 and 1946, field studies on anostracan phyllopods (fairy shrimps) were continued in Portage, Summit, Stark, and Crawford Counties of northeastern Ohio. Reports on this work for the years 1941–1944 inclusive have already been published (Dexter and Sheary, 1943; Dexter, 1943 and 1946). This paper presents the observations on seasonal and geographical distribution of fairy shrimps from a study of more than eighty pools and ponds during the fifth and sixth years of an annual survey, including a week by week life history study in two ponds throughout the entire fairy shrimp season, together with new information on ecological relationships of this group of sporadic crustaceans. Also, there is added a compilation of collecting records of the Anostraca from other sections of Ohio.

Acknowledgment is made to those who have kindly contributed specimens and records to this study. Their names are given in the paper in connection with their specific contributions. We are indebted to Dr. Folke Linder of Uppsala, Sweden, and to Dr. Edwin P. Creaser for service rendered in settling certain taxonomic problems. We thank Dr. Kenneth L. Kelley for making the collections for two weeks from the two ponds in which life history studies were in progress while the senior writer was out of the state.

REVIEW OF FIELD COLLECTIONS—SEASON OF 1945

In 1945, 83 pools and ponds were visited. Sixty-five of these had been studied and reported upon in previous years. Six new stations were added in Portage County and four new ones in Stark County. Eight stations, which had been established near Bucyrus in Crawford County by the junior author in 1944, were also added to the survey. All pools known to have contained fairy shrimps at any time during the previous four years were studied. Four pools were dry when visited. Twenty-three contained no specimens, but only one of these (C3) was ever known to be populated with Anostraca. Fifty-six stations yielded specimens of ***Eubranchipus vernalis*** (Verrill). Six of these had not contained fairy shrimps since first investigated in preceding years (two in 1941, two in 1942, and one each in 1943 and 1944). Eight of the new stations contained *E. vernalis*. Six of the eight pools containing this species in Crawford County were known to be populated with the same species when investigation was first made in that county in 1944. Five pools in the other counties (one in Portage, two each in Summit and Stark Counties) which had fairy shrimps at various times in past years, but not in 1944, had them return in 1945. Ten pools had a definite increase in abundance in 1945 over that of 1944 while only six suffered a marked decrease in abundance. The largest specimen of *E. varnalis* collected in this study to date was a female which measured 32 mm. and was collected from pond S4 on April 1, 1945.

In a previous report (Dexter, 1943), ***Pristicephalus bundyi*** (Forbes) was recorded from Ohio for the first time. In a critical revision of certain groups of Anostraca, Linder (1941) suggested that probably this species should be placed in the genus Chirocephalopsis, a genus which has not formerly been recorded for North America. In conversation with Dr. Linder in the summer of 1946, when he was in this country working on the phyllopod clolections of the United States

National Museum, it was learned that he is quite convinced of the need for such a change. For that reason the present paper will follow such a classification. *Chirocephalopsis bundyi* (Forbes) was not collected in Ohio after the original find in 1942 until the season of 1945 when a single specimen was collected from the original site (C7) on March 24 by Miss LeMoyne Unkefer, a student at Kent State University, and another specimen collected by the writers on April 8 from a pool (C18) several hundred yards distant from the other. This second pond was known by the junior author to contain *E. vernalis* in the seasons of 1942 and 1943 as well as in 1945, but no fairy shrimps were found there in 1944. Both specimens of *C. bundyi* were found among specimens of *E. vernalis*.

TABLE I

Summary of Field Collections of Fairy Shrimps—Seasons of 1945 and 1946

P = Portage County
S = Summit County
C = Stark County
Cr = Crawford County

	1945				1946			
	P	S	C	Cr	P	S	C	Cr
Number of pools studied	44	12	19	8	35	13	20	15
Pools dried out at time of visit	4	0	0	0	3	0	2	0
Pools without fairy shrimps	17	3	3	0	21	6	3	0
Pools containing *E. vernalis*	23	9	16	8	11	7	15	15
New records of *E. vernalis* (first appearance known)	P8 P23 P42 P54 P90	0	C17	0	P93	0	C15	0
New stations containing *E. vernalis*	P95 P96	0	C16 C19 C20 C21	Cr7 Cr8	0	S21	C22	Cr9 thru Cr15
Pools from which *E. vernalis* disappeared	0	0	C3	0	P18 P23 P30 P37 P40 P42 P50 P55 P58 P80 P90 P96	S3 S4 S11	C6	0
Return of *E. vernalis*	P37	S3 S4	C10 C18	0	0	0	0	0
Increase in abundance of *E. vernalis*	P17 P18 P30 P55 P91	S2 S5 S12 S14	C14	0	P54	0	C9 C10 C16 C21	Cr4 Cr5
Decrease in abundance of *E. vernalis*	P40 P79	0	C2 C8	Cr4 Cr6	P8 P17 P88 P91	S1 S2 S5 S12	C7 C8 C11 C12 C14 C18	0
C. bundyi found with *E. vernalis*	0	0	C7 C18	0	0	0	0	0
E. holmani found with *E. vernalis*	0	0	C21	0	0	0	0	0

A third species of Anostraca for the State of Ohio was discovered for the first time in 1945. From a small collection of fairy shrimps taken in a shallow pool (C21) on Route 30 between Canton and Massillon on April 25, there was found a single male specimen of ***Eubranchipus holmani*** (Ryder). This species, under a variety of names, has been reported previously from the following localities: New Jersey (type locality); Long Island, New York; New Haven, Connecticut; Chincoteague, Virginia; and Tiptonville, Tennessee The taxonomy of this species has been much disputed (see Creaser, 1930), but our specimen was determined by both Dr. E. P. Creaser and Dr. Folke Linder as species ***holmani*** as described by Ryder, and it is the opinion of Dr Linder that it should be assigned to the genus Eubranchipus. While Dr. Creaser at first suggested that it be placed in the genus Branchinella, it seems best to record it as ***E. holmani*** in view of Linder's forthcoming revision of the North American Phyllopoda

Table No. 1 gives a summary of the field collections for 1945 and compares the results of that year with 1946 The map on page 33 of a previous report (Dexter, 1946) may be consulted for the location of many of the stations mentioned in this paper. The season of 1945 was the most favorable one encountered in six consecutive years of collecting. Every pool, except one, in which fairy shrimps were ever known to occur in past years contained ***E. vernalis*** in 1945. It was the only year in which all of the three species known from Ohio were collected.

REVIEW OF FIELD COLLECTIONS—SEASON OF 1946

During the sixth survey a total of 83 pools and ponds including nine new stations were visited. Five had dried out by the time they were reached Thirty contained no fairy shrimps, including 16 which were known to have ***E. vernalis*** the preceding year. Three of these had had this species for five years, two for four years, three for three years, and four each for two years and one year respectively. Forty-eight stations contained ***E. vernalis*** in 1946 Two of these were inhabited for the first time since being studied over a period of two and three years respectively. All nine of the new stations added to the survey this year contained specimens One of these (C22), however, yielded but a single specimen. The collections from seven ponds were considerably more abundant than those obtained from the same place the preceding year, while 14 ponds had a much smaller population than in 1945. Less than a dozen specimens were collected from five of these 14 stations The largest specimen collected in 1946 was a female which measured 33 mm. and was taken from pool Cr4 near Bucyrus. Neither ***Chirocephalopsis bundyi*** nor ***Eubranchipus holmani*** was collected in 1946.

It is interesting to note that some other collectors in Ohio experienced a similar failure to find fairy shrimps as often in 1946 as in former years. However, a few also failed to find them in expected places in 1945 when the writers experienced the best year of collecting. Some of those reporting positive records in the past (see Dexter, 1946), but who failed to find specimens in the same places in later seasons are as follows: Miss Rose Azary collected ***E. vernalis*** on April 3, 1945, from the same pool near Painesville from which records were reported for 1944, but in 1946 she failed to find it there. Another pool in the same pasture, however, contained specimens for the first time in three years. Mr. Alfred Linscheid found ***E. vernalis*** to be abundant on April 10, 1945, in the Warrensville Heights swamp as in previous years. In 1946 three attempts were made to collect it from the same location, but he could find only two specimens there which were taken on March 28. Dr. William A. Dreyer failed to find fairy shrimps in the three ponds previously reported near Goshen on field trips made on February 25, 1945, February 26 and March 8, 1946. Dr. William C. Stehr found a new locality record for ***E. vernalis*** in Athens County in 1945 but did not find it in those pools reported for that county in past years. In 1946 he did not find fairy shrimps in any of the pools he examined including one which had been inhabited for many years up until 1943. Mr. Ernest Vickers did not find any fairy shrimps in the pools of Mill Creek Park at Youngstown during the spring of 1945 and 1946.

The sex ratio of ***E. vernalis*** collected in past years from Portage, Summit and Stark Counties has been reported earlier (Dexter, 1946) to average 1 male: 1.5

females. This ratio was approximately true for all samples taken in Portage and Summit Counties. A sample from some Stark County ponds taken in 1943, however, was found to have a ratio of 1 male: 0.5 female. Another sample of 169 specimens collected from these same ponds, located west of Canton, still showed a predominance of male specimens in 1946 with a ratio of 1 male: 0.8 female During the same season a sample of 386 specimens taken from the ponds in Crawford County had a similar ratio of 1 male: 0 75 female. Apparently the sex ratio is variable from one locality to another, and at times males are more numerous than females.

In 1943 an experiment was attempted to introduce *E. vernalis* into a temporary pool which did not contain this animal. On March 25, 32 male and 68 female specimens of this species collected from pond P7 were transferred to pond P42 which contained no fairy shrimps since the survey began in 1941. One week later two specimens were collected during a cursory re-examination of the pool. That fall the field in which the pool is located was plowed and planted with winter wheat after lying fallow for several years. Water collected in the field as usual during the following spring, but fairy shrimps could not be found after a thorough sampling on two different occasions. In the spring of 1945, however, one male and one female specimen were collected there The next year no specimens could be found. The cultivation of the field may have prevented the successful introduction of fairy shrimps. Where they have become well established, however cultivation does not seem to interfere with them. Two of the most productive pools in Crawford County (Cr5 and Cr8) are in cultivated fields.

COMPARISON OF THE LIFE HISTORY OF EUBRANCHIPUS VERNALIS IN TWO PONDS

Pond P7 filled with rain water for the first time in 1945 on February 21. Three days later metanauplii of *E. vernalis* were collected which averaged 1.25 mm. in total length. On March 10 only a single specimen was found in the plankton samples. This measured 5.5 mm. whereas on this date during the preceding year the shrimps were only four days old and measured 2.5 mm. Subsequent collections in 1945 yielded abundant specimens until April 7 when the last collection for the season was made from this pool. After that date the water disappeared rapidly. Warmer water in 1945 than in the previous year resulted in a more rapid rate of growth, earlier maturity, and uniformity of size for adult specimens over a period of three weeks. Collections of 1944 were made until April 22, although the length of the season for fairy shrimps was the same each year, being a little more than six weeks. While the pond refilled on May 17, 1945, no second hatching of fairy shrimps was found to have taken place as occurred in May of 1943.

In 1946 pond P7 filled from melted ice in the second week of January. The first collection of *E. vernalis* was made on January 12 and averaged 2.5 mm. in length. This early hatch was destroyed in about two weeks, however, when the pool froze to the bottom and remained frozen solid for three weeks. Ferguson (1939) reported that *E. vernalis* is not found in pools in the Ontario region with a depth less than two and one-half feet because they would be frozen to the bottom during severe winters. In the Ohio region this does not hold true as we shall see. On February 14 rain melted the ice and refilled the pond. By the end of three days, *E. vernalis* had hatched again and measured 1.25 mm. On February 23 they were about the size of those collected on February 24, 1945. The water in the early season of 1946, however, was cooler, resulting in a slower rate of growth and a smaller maximum size attained by the time the pool dried out. The season of this second hatch, the only one which reached maturity, was again a little over six weeks in duration. Table No. II summarizes the life history of this fairy shrimp in pond P7 for the two years.

Pond P88 in the same pasture with pond P7 near Brimfield, also filled with rain-water on February 21, 1945. While the first specimens, collected on Feb-

TABLE II

Comparison of Life History of *Eubranchipus vernalis* in Pond P7 in 1945 and 1946

1945						1946					
Date	°C	pH	Length in MM	Growth in MM	Notes	Date	°C	pH	Length in MM	Growth in MM	Notes
						1-5	1.0	5.9			Pond ½ full with coat of ¾ in. soft ice, 6-8 in. water No fairy shrimp
						1-12	4.4	5.4	2.5		Pond ½ full. *E vernalis* found—first record in 1946.
						1-19	0.5	5.5	3.5	1.0	3 inches ice over pond, 3-4 in. water under ice.
						1-26	.	.		.	Pond frozen to bottom Ice 4-5 inches.
						2-2		..	.	.	Pond frozen to bottom. Ice 4-5 inches.
						2-9	3.0	5.3	.		Patches of ice slowly melting, few puddles under ice, in. or 2 deep. No fairy shrimps found
						2-17	1.6	5.3	1.25		Pond refilled on 2-14 from rain and snow Froze over early a m. of 2-17 *E vernalis* hatched out for 2nd time. Collected under 1 in of soft ice.
2-24	2.8	5.9	1.25		Rain filled pond on 2-21 1st collection in 1945. Plankton sample taken under ice.	2-23	0.5	5.5	1.75	0.5	Collected under 2 in of soft ice
3-3	6.8	6.0			None found in plankton sample. Pond overflowing	3-2	4.0	5.9	1.50		Pond flooded over One specimen of *E. vernalis* only Flood waters may have scattered fairy shrimps Ice practically gone
3-10	5.0	6.1	5.50	4.25	One specimen only collected in 2 plankton samples	3-10	2.2	6.0	5.4	3.9	Pond fully covered with ⅝ in. of ice Froze over 3-9 after a wk. of warm weather (50-60° F.) Many pink *E. vernalis* specimens collected Few metanauplii also collected
3-17	19.0	6.4	11.53	6.03	Specimens fairly numerous. Pond ⅓ dried up.	3-15	11.7	5.9	8.7	3.3	Pond full Orange-pink in color. Immature.
3-26	18.3	6.7	17.55	6.02	*E. vernalis* abundant. Water level same as for 3-17. Egg sacs developed.	3-23	16.0	5.7	15.9	7.2	Pond ½ full. Eggs developed.
3-31	11.7	6.3	17.45	... .	Normal coloration for adults. Water level approximately the same.	3-29	19.5	6.5	16.3	0.4	Pond reduced to scattered puddles Last record of *E. vernalis* in pond P7 for 1946.
4-7	15.3	6.2	17.98	0.53	Pond about two-thirds dried up.	4-5		. . .		..	Pond dry
4-14	......	....	....	....	Pond nearly dried up. Scattered, shallow puddles only. No fairy shrimps.						
4-22	......	......	....	... . .	Pond completely dried up.						
5-26	17.2	6.2	....	.... . .	Pond refilled on 5-17. 5-6 in. of water in places. No fairy shrimps.						

ruary 24, averaged the same size as those in pond P7, it seems that this initial hatching did not survive. A week later the specimens in pond P88 were no larger than those first collected indicating a second hatch had taken place. Unfortunately, none was found in the plankton samples taken from pond P7 that same day which could be used for comparison. However, on March 10 the shrimps in pond P88 were only 1.7 mm. in size as compared to a length of 5.5 mm. in pond P7. During the succeeding weeks, specimens in this pond (P88) were consistently smaller, grew less rapidly, and attained a somewhat smaller maximum size than in pond P7. They did, however, persist in the deeper pond for two weeks longer than in P7, and on the date of the last collection from that pond, the presence of immature individuals in P88 indicated that hatching had taken place there over a longer period of time. Somewhat cooler water on the average and the greater volume of water in P88 may explain in part these differences. On April 22, 1945, the last weekly collection of fairy shrimps for the season was made in pond P88. On the same date one year previous, the first collection of the season for this pond was made since it did not fill that year until April 11 and contained *E. vernalis* until May 13. Water remained in the pond in 1945 for many weeks after April 22 and the temperature did not go above the toleration limit, but the fairy shrimps disappeared soon after reaching maturity that year in this pond.

On January 12, 1946, metanauplii of 2.0 mm. size were collected. None had been found in the water under the ice a week earlier. They lived for a little more than three weeks, most of the time under ice, increased in size to 4.0 mm., and then disappeared. In this case it was not because of freezing to the bottom as it was in pond P7. Rather, the water below the ice turned yellow in color and became filled with gases of puterfaction. After thawing from warm rain on February 14 and filling several inches deeper, the pond refroze. Fairy shrimps were not found again until February 23 when a single specimen measuring 5.0 mm. was collected. Without much question this was a survival from the original hatch and was the last one seen from that group. One week later another specimen, the only one taken in several plankton samples, measured 1.2 mm., indicating a new hatch of shrimps had taken place after the polluted water had cleared. Those hatching at this time were not numerous, however, since subsequent samples were always small. Also, it appears that the second hatching took place over a period of days since the average size of the sample dropped abruptly on two occasions as the earlier hatched shrimps matured, died off, and left the immature and smaller ones still living in the pond. A similar situation was found in a population of *E. serratus* in a pond in east central Illinois (Dexter and Ferguson, 1943). Having hatched later, and living in a deeper pond which did not dry out until summer, the fairy shrimp population of pond P88 persisted for three weeks longer than that in pond P7. This second population of *E. vernalis* in station P88 paralleled very closely the life history of this species in the same pond the year previous. Table III presents the data of environmental conditions and life history of *E. vernalis* in this pond for the years 1945 and 1946.

TABLE III

COMPARISON OF LIFE HISTORY OF *Eubranchipus vernalis* IN POND P88 IN 1945 AND 1946

1945						1946					
Date	°C	pH	Length in MM	Growth in MM	Notes	Date	°C	pH	Length in MM	Growth in MM	Notes
						1-5	1.0	5.3			About 5 in. of soft ice, melting around edges of pond. Free water at margin of pond. No fairy shrimps.
						1-12	4.0	5.4	2.0		Pond ⅓ full. First record of *E. vernalis* in 1946.

TABLE III—*Continued*

Date	°C	pH	Length in MM	Growth in MM	Notes	Date	°C	pH	Length in MM	Growth in MM	Notes
						1-19	2 2	5 6	3 0	1 0	2 in. of ice over pond. About 15 in. of water below ice
						1-26	0 0	5 3	3 5	0 5	4 in ice. About 14 in of water below ice.
						2-2	0 3	6 1	4 0	0 5	6 in. of ice About 10 in. water below ice
						2-9	1 4	5 7			4 in of ice. About 12 in water below ice Water yellowish and has odor of decay No fairy shrimps found.
						2-17	1 6	5 8			Pond thawed with warm rain on 2-14. Filled several ir deeper from rain and snow. Refroze early a m. of 2-17 with about 1 in. of ice. No phyllopods found
2-24	5 0	5 2 or less	1 25		Rain partly filled pond (depth of 5 in) on 2-21 Plankton sample taken under ice for most part	2-23	1 0	5 7	5 0		One specimen of *E. vernalis* collected under 2 in of soft ice Survival from original hatching.
3-3	6 9	5 2 or less	1 25	0	Depth has increased to 6-10 in Pond about ¼ full Many of the larvae have probably hatched since the previous collection	3-2	5 0	5 7	1 2		One specimen only of *E. vernalis* collected. Pond about ¾ full, ice mostly gone . recent hatching probably
3-10	4 0	5 4	1 70	0 45	pond slightly deeper	3-10	2 7	5 7	8 5	7 3	One specimen only collected under ⅜ in of ice Pond full Froze over on 3-9 after a week of warm weather (50-60° F) No metanauplii found.
3-17	17 5	6 1	3 72	2 02	Pond deeper (2 ft deep)	3-15	12 2	5 5	13 9	5 4	Pond full Specimens uncommon Eggs developed
3 26	15 3	6 7	13 70	9 98	*E vernalis* abundant Egg sacs developing	3-23	9 0	5 5	10 5		Pond ¾ full Immature
3-31	12 8	6 0	15 25	1 55	Egg sacs developed. Color normal for adults Pond full (about 4 ft deep)	3-29	20 0	5 9	11 1	0 6	Pond ²/₃ full Small population
4-7	12 8	5 9	16 03	0 78	Water level nearly the same. Some small, immature individuals indicate a late-hatching group.	4 5	12 0	5 7	11 3	0 2	Pond ²/₃ full. Eggs developed.
4-14	14.0	5 9	16 60	0 57	Water level beginning to drop. *E vernalis* present but not numerous Medium and adult sized individuals collected	4-12	15 0	6 2	7 5		Pond ½ full. Two specimens only collected Immature
4-22	10 0	6 2	13 00		Pond about ¾ full. Only two specimens of *E vernalis* collected	4-20	16 0	6 1	13 25	5 75	Pond ¹/₃ full Two specimens collected One was being eaten by a Dytisid larva Other was mature Last collection of season
4-28	12 0	5 9	. .		Pond about ¾ full. No fairy shrimps.	4-27				. .	Pond ¼ full No fairy shrimps.
5-26	17 0	6 4			Pond about full. No fairy shrimps						

OBSERVATIONS OF FAIRY SHRIMPS IN POLLUTED WATER

On a number of occasions relationships have been observed between fairy shrimps and their occurrence in polluted water. *E. vernalis* was found to be numerous in pond C10 west of Canton in 1942. Later that year a quantity of yellow clay was placed in the pond to fill in a portion of it. The following spring the water was heavily silted with the clay much of which remained in a colloidal suspension. Only a single specimen of fairy shrimp could be collected from this water after several attempts were made. In 1944 none could be found. The next year, with turbidity somewhat less, two were collected. By 1946 the clay had settled to such an extent that the water was somewhat clear again. That year the fairy shrimps returned in good numbers in that portion of the pond farthest from the deposit of silt where turbidity was at a minimum. In station C11, an extensive swamp-pond, voluminous inwash of heavily silted water from eroding clay banks may have been responsible for the scarcity of *E. vernalis* there in 1946. It is a common observation that when sediment is stirred up from the bottom of a pond containing fairy shrimps, they swim away from the cloud of silt. Sometimes great quantities of them will be seen swimming away at the very edge of the advancing cloud of silt. Advantage is taken of this fact in collecting them from ponds which have a bottom of fine sediments. It may be that a high concentration of silt interfers with the branchial respiration of phyllopod Crustacea.

As mentioned in an earlier section of this paper, *E. vernalis* which hatched in early January of 1946 in pond P88 lived under ice for at least three weeks. By the fourth week the water under the ice had turned yellowish and possessed a very strong odor of putrefaction. At this time the fairy shrimps disappeared before reaching a size over four millimeters. After the melting of the ice and the addition of rain-water over a period of several weeks, the fouling condition of the pond was cleared up. A new hatch of *E. vernalis* took place on or about March 2. These lived to maturity. In another case, station Cr10 was found to have abundant fairy shrimps on April 6, 1946, even though the water was yellowish and malodorous with putrefaction. Two weeks later, however, no specimens were living in this pool while they were still common in pond Cr11 nearby which showed no signs of putrefaction. Gases of putrefaction confined by a covering of ice seem to be most detrimental to the maturing stages of the shrimp. Mr. Donald S. Lacroix, of the Amherst (Mass.) High School, made a similar observation the same year. He collected numerous immature specimens of *E. vernalis* from under the ice of a pond at Cushman, Massachusetts, from December 22, 1945, until February 16, 1946. The ice was melted off by March 10, and on the 17th of the month only two immature specimens could be collected. After that date no specimens were seen, and apparently they did not reach maturity. Once the pond had lost its ice, the water was discovered to have a "strong odor of sulphur from decaying vegetation." The species was still living on April 17 in another pond a few miles away which had not suffered from putrefaction. In one of the bog ponds of the present study, C15, *E. vernalis* has never been collected in the central portion of the bog. There the growth of vegetation is rank and the surface is ice covered at the season when fairy shrimps are undergoing development. At the edge of the bog, however, where shallow scattered pools occur which lose their ice early and hence do not accumulate gases or lose all of the oxygen content, *E. vernalis* has been collected in small numbers.

While *E. vernalis* seems to be sensitive to suspended silt and to gases and depletion of oxygen through putrefaction, it is known that it can live in ponds polluted with an oil slick. Pond C21 in a rubbish dump located on Route 30 between Canton and Massillon, was covered with an oil slick during the spring of 1946, yet abundant specimens of *E. vernalis* were collected there on April 9 and 17. On the latter date the volume of the water was reduced to a tub full, but the fairy shrimps were still abundant. It was in this one and another rubbish-filled pond (C19) that *E. vernalis* persisted the longest in the Stark County stations in the seasons of 1945 and 1946. Mr. Frederick R. Burrill of the Peabody Museum at Salem, Massachusetts, sent us some *E. vernalis* that were similarly collected on April 25 and May 9, 1946, from a dump pool which acquires each year considerable rust and oil from refuse thrown into it.

The most remarkable case of toleration of fairy shrimps to adverse physical conditions which has come to the attention of the writers is one involving the brine shrimp *Artemia salina* (L.). A sample was collected by Dr. Seville Flowers of the University of Utah from Great Salt Lake on January 16, 1945. Having lost the address to which they were to be sent, he kept the shrimps in culture in his laboratory until the following year. They were then forwarded to Kent, Ohio, in February, arriving on the 13th of the month. The specimens were shipped in a sealed glass coffee jar partly filled with salt water. Upon arrival the water was lukewarm in temperature—considerably above room temperature—completely clouded with a fine black suspension of silt, and was foul smelling with gases of decay. Mathias (1937) reported that this species will perish in temperatures over 40 degrees C. At first it did not appear that any of the brine shrimps survived, but several days later, after settlement of some of the suspended material, four specimens were found still alive. These were placed in a liter beaker where they reproduced through many generations and maintained a population of about eight to ten individuals. Fresh water species are not so hardy. They will often perish over night in such small containers as a coffee jar even though they are kept in cool, clear pond water. On one occasion the culture of *Artemia salina* was neglected so that the water was allowed to evaporate to a point where large masses of salt crystallized out on the bottom. The shrimps continued to live in the concentrated salt solution for some time. Water was later added and the culture is still living and thriving nearly three years after its collection.

COMPARISON OF OHIO FAIRY SHRIMPS WITH THOSE FROM INDIANA, MICHIGAN, AND ILLINOIS

Mr. Paul Donaldson, a student at Kent State University, discovered on April 13, 1946, a single pasture pool at Middlefield inhabited with an abundance of *Chirocephalopsis bundyi*. This was the first record of a large population of this species in the State of Ohio, and the first state record of its occurrence as the only species of anostracan phyllopod in a pool. The previous records were based upon a few individuals found mixed with large numbers of *E. vernalis* from the Canton ponds as discussed above. In the spring of 1945, Dr. Frank E. Eggleton of the University of Michigan sent some large samples of fairy shrimps collected that year near Ann Arbor. All of them were *C. bundyi*. The following spring Dr. J. Arthur Herrick, also at the University of Michigan at the time, collected fairy shrimps from many localities in the Ann Arbor region. Eight of his collections contained many specimens of this same species with a few of *E. vernalis* mixed with them. Since the collections from Ohio and Michigan were the opposite in composition, all published records and records known to the writers on distribution of the common species of fairy shrimps in the north central states were compiled for comparison. Our present knowledge of the occurrence of the three common species in that area indicates that this region includes the extremities of distribution of all three. *E. vernalis* is abundant in Ohio, much less common in Michigan and Indiana, and rare in Illinois. *C. bundyi* is rare in Ohio and Indiana, not found in Illinois, but abundant in Michigan. *E. serratus* is abundant in Illinois, rare in Indiana and not found in either Ohio or Michigan.

ADDITIONAL RECORDS OF ANOSTRACAN PHYLLOPODS COLLECTED IN OHIO

Since the publication of all known records of fairy shrimps from Ohio in the preceding reports of this survey, a number of new localities including records from five new counties have come to the attention of the writers. See Table IV.

TABLE IV

NEW RECORDS OF ANOSTRACAN PHYLLOPODS COLLECTED IN OHIO

I. NEW COUNTY RECORDS

COUNTY	COLLECTOR	LOCATION	SPECIES	NOTES
Geauga	Paul Donaldson	Middlefield	*C. bundyi*	Collected in abundance 4-13-46 from a single pasture pool. Not found in similar pools nearby.
Ashland	C. H. Kuehnle, Lincoln High School, Canton	Miflin	*E. vernalis*	Four specimens collected in a shallow field pond 3 miles east of Miflin on 4-19-46.
Hardin	Carl Vernard, Ohio State University	Mt. Victory	*E. vernalis*	Common in a woodland pool on 3-17-45, 1½ miles northeast of Mt. Victory.
	R. A. Dobbins, Ohio Northern Univ.	Ada	*E. vernalis*	Occur commonly each year in a small pond 3½ miles northeast of Ada, and in a swamp pond ¼ of a mile southwest of Ada. Collections from both made 3-25-45 and 4-8-45
Preble		Jackson Township	*E. vernalis*	Collected in April of 1944 by a student at Miami University. Reported by Dr. N. T. Mattox
Washington	H. R. Eggleston, Marietta College	Marietta	Unknown	Specimens collected for many years in a swamp between Green and Seventh Streets in Marietta, and in a temporary pool at Squaw Hollow, 3 miles west of city.
II. NEW RECORDS FROM COUNTIES PREVIOUSLY REPORTED				
Mahoning	Shirley Williams	Canfield	*E. vernalis*	Abundant on 3-24, 25-45 in 2 small pools and one swamp pond.
Cuyahoga	Charles O. Masters	Cleveland	*E. vernalis*	Collected in abundance every year between 1932-41 in a hog wallow on East Forty-ninth Street near Canal Road
Wayne	R. V. Bangham, College of Wooster	Wooster	*E. vernalis*	Collected from a pool on farm of Prof. James Anderson 4-20-46, 2 miles west of Wooster. Previous record from here reported as species unknown.
		Rittman	*E. vernalis*	Collected by school boys 4-15-46 from a temporary pool northeast of Rittman.
Marion	Carl Venard	Marion	*E. vernalis*	Collected 3-17-45 from several pools 1 mile southwest of Marion in a pasture. Not numerous. First determined specimens from this county.
Mercer	Clarence F. Clark, Ohio Div. of Conser. and Nat. Resources	Granville Township	*E. vernalis*	Collected 4-2-42 from a temporary pool, and from a woodland pool in section 19 on 3-18-45
Auglaize	Clarence F. Clark	Jackson Township	*E. vernalis*	Collected 4-3-46 from a woodland pool in section 7.
Delaware	W. F. Hahnert, Ohio Wesleyan Univ.	Delaware	*E. vernalis*	Small collection made 3-20-46 from overflow pond of Olentangy River.
		Kilbourne	*E. vernalis*	Large collection made by a student 3-24-46 from a field pond northeast of Kilbourne
Athens	William C. Stehr, Ohio University	Chauncey	*E. vernalis*	Small numbers collected from a temporary pool along U. S. route 33, northeast of Chauncey, on 4-4-45.

Collecting records have now been reported from 28 counties exclusive of the four studied in some detail in this survey. Thus, 32 of the 88 counties are known to contain definite locality records of fairy shrimps. Nine new localities for previously reported counties are also listed in the table. All of those with known determination of species are for ***Eubranchipus vernalis*** except the one from Geauga County which is for ***Chirocephalopsis bundyi***. This species, which has also been collected in small numbers mixed with *E. **vernalis*** populations, and a single specimen of *E. **holmani*** collected with *E. **vernalis*** as discussed earlier in this paper, brings the state list of species to three. Determinations of the species were made by Dr. Folke Linder, Dr E. P. Creaser, Dr. N. T. Mattox, Dr. William C. Stehr, and the senior writer.

SUMMARY

1. Field studies on the occurrence and distribution of fairy shrimps in Portage, Summit, Stark, and Crawford Counties in northeastern Ohio were continued in the winter and spring seasons of 1945 and 1946.

2. Crawford County was added to the annual survey area after preliminary collecting there in 1944.

3. The populations of 1945 and 1946 are compared regarding new appearances, reappearances, disappearances, and fluctuations of abundance from year to year.

4. The season of 1945 was the most successful season during the six years of the survey. Only one pool of those known to be inhabited in former years failed to contain *E. **vernalis*** in 1945

5. Three species of anostracan phyllopods were collected in 1945, namely. ***Eubranchipus vernalis***, *C**hirocephalopsis bundyi*** (formerly known as ***Pristicephalus bundyi*** and *E. **bundyi***) and *E **holmani***. The last named is reported from Ohio for the first time.

6. Only one species, *E **vernalis***, was found in 1946 in the regular survey ponds, and this species was not as commonly found as in the preceding year.

7 The life history of *E. **vernalis*** in two ponds is tabulated in detail for 1945 and 1946. Comparisons are made between them each year and between their populations of 1945 and those of 1944.

8. The sex ratio of *E. **vernalis*** from the new ponds in Crawford County was 1 male: 0.75 female, similar to the ratio in ponds near Canton in Stark County, but unlike the 1. 1.5 ratio usually found in Portage and Summit Counties

9 *C. **bundyi*** was found in abundance, and was the only fairy shrimp present, in a pool in Geauga County in the spring of 1946. This was the first such record for the state.

10. *E. **vernalis*** was eliminated from ponds in which colloidal clay and excessive gases of putrefaction were present. Oil slicks, on the other hand, did not interfere with populations of this species in several cases observed.

11. The three common species of fairy shrimps in Ohio, Michigan, Indiana, and Illinois are compared in regard to their distribution and relative abundance.

12 Five new county records of Anostraca and additional records in eight other counties are recorded for the State of Ohio. Thirty-two of the 88 counties in the state have now been reported with positive records of fairy shrimps.

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MYRMECOLOGICAL TECHNIQUE

II. IN COLLECTING ANTS, THE USE OF THE COLEOPTERIST, THE HEMIPTERIST AND THE ECONOMIC ENTOMOLOGIST WITH HIS LIGHT OR BAIT TRAP.[1]

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The writer has been much impressed with the quality of ants as regards new and rare species brought to him by friends who collect ants in unusual ways. The average collector of ants looks down on the ground. In many groups such as the *Formica rufa* group and the *sanguinea* group rare species will nest in the same area as that occupied by very abundant species but a collector cannot afford to sample all nests so too frequently he misses the occasional nest of a rare species which is sandwiched in with abundant nests of some similar-appearing common species. Unfortunately for the ground-examining collector, the ants least often captured are those which range over the foliage of trees and large bushes—a regularly neglected collecting area The arboreal stratum is above the ground and too frequently requires skilled climbing for a thorough examination. Coleopterists and Homopterists find many of their rare things up trees and on bushes and have various means of collecting them—means which are not used commonly by ant collectors.

1. *Coleopterists.*—Common equipment with the Coleopterists is a canvas umbrella which can be opened in an inverted position under a bush or the limbs of a tree and then the bush or the limb jarred with a short club whereupon insects running on the foliage fall into the inverted *umbrella. Any ants* will usually be found to be all of one species or a mixture of seldom more than three. These, of course, are arboreal ants which are hunting Homoptera for honey dew. The difficulty with this method of collecting is that the Myrmecologist gets no idea of the nest, its location, or of other castes than the field worker ants. Too frequently the traveling ants are widely dispersed so that the collector gets but a few specimens of a species. We have been particularly impressed with the high quality of bush and tree ants collected in this manner by Professor and Mrs. Josef Knull.

2. *Homopterists.*—Common equipment with the Homopterist is a heavy-bagged beating net, a light weight tightly covered tin can of about one quart capacity which is charged with potassium or sodium cyanide and pill boxes to carry specimens to the lab.

The insects are swept up from bushes, low trees, weeds, grasses, etc. These are shaken into the bottom of the net and the net bag is then stuffed into the cyanide can, or the contents of the net are themselves shaken into the can when the lid is clapped on until death of the catch. Very enthusiastic homopterists may carry two such cans hung at their belt. Such collectors can be heard a long ways off as the cans bang against each other. A lighter net may be used for sweeping herbage.

This method of collecting is of only moderate interest for the ants swept up, as these are mostly ground species which can be collected directly from nests by the myrmecologist where notes on the nest may be collected also. It is not recommended for ants although a myrmecologist can learn much concerning the association of ants with certain species of the honey dew secreting Homoptera.

The Homopterist interested in aphids which are nearly always attended by ants usually collects these very slow moving insects with a pair of tweezers and stores them in one dram vials of seventy per cent alcohol. Such collectors when interested in the association of aphid and ant bring in enough ants of one species to interest the ant student because the latter has to have a series of worker ants as a minium for identification. Seldom are two or more species of ants associated with one close group of aphids. Ant property rights enter in. For first exploration in a new area such collections have considerable value as most ants can be identified from a fair series of a dozen workers. We have had such series from the inter-mountain area of Utah, Idaho and western Colorado, collected by George Knowlton, Clyde F. Smith and other western students of aphids. Unfortunately the area mentioned is of "island distribution" where an ant species with mountain and valley barriers may show many subspecies which are difficult to determine from workers only Characters of male, queen and nest are lacking. We do recommend the next.

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[1] I. The use of ether in collecting ants. Ohio Jour. Sci. XLVI (1): 10–12. 1946.

3. *The Hemipterist with cyanide dust (Cyanogas) and ground cloth.*—Cyanide dust used in a small hand dusting gun to blow a cloud into bushes and small trees 12-18 feet high brings down as miscellaneous a lot of insects as any collector might desire. With a large sheet or two spread on the ground to catch the dead and the stunned insects the collector has ample time to select specimens of the groups in which he is interested. This is one of the most satisfactory methods of which we know for collecting in the tops of small trees. It is not a rush operation Few victims attempt to escape and have to be collected in a second stage of the process as is necessary in using a beating net or a club and umbrella. Doctor E. P. Breakey while a student at O S. U. brought us several species of rare ants taken thus while collecting Hemiptera He preferred the use of cyanide dust to any other method of collecting.

As ants are in general ground nesting insects the myrmecologist hesitates to carry the extra equipment necessary. His interest is focused more than 90 per cent on the ground. Further, only a few ants are tree ants. However such as nest in the ground and from the ground hunt for honey dew producing Homoptera on the foliage of bushes and trees usually hunt within range of a dust gun. In the north Homoptera are usually distributed up to 15 or 20 feet on aspens which trees are more or less deserted by them when the trees have developed above this height. In the south the large, very vigorous Alleghany mound building ant ***Formica rufa exsectoides*** collects honey dew from the stinking scale of yellow poplar (Lyriodendron) on trees fifty or more feet high, while certain species of Camponotus on oak appear never to contact the ground. Such species are so high other means of collecting have to be used. An agile young assistant with a saw and a rope to let down all dead limbs is very effective. A dust gun for such trees and such ant species to sample the ants on lower limbs before climbing might be useful. We have not tried such sampling

The dust gun with 10% DDT or better yet 10% benzene hexachloride should be tried out. The latter has been recommended to the author for general bush collecting where a sheet can be spread on the ground. We have not seen it tried. The latter two dusts can be used freely with little danger to the operator but cyanide dust ***must*** be used down the wind. With the latter the collector could get a dose that would give him a thumping headache which might carry over into eternity.

Dusting for ants has two limitations. From Tennessee to northern Ohio it is effective probably because of the many species of shrubs and trees. Some valleys in eastern Tennessee have a hundred or more species of trees. These are fed on by equally numerous species of Homoptera. It is ant territory. On the Canadian border species of shrubs and trees are less numerous and in larger areas of pure stands. Many more are conifers and for some reason ants are not numerous in species on conifers. Perhaps the latter do not carry many Homoptera. The resins and oils of conifers may be unpleasant to Homoptera or ants or to both. A possibility is that the more primitive genera of Homoptera usually associated with conifers do not produce as much honey dew as the more highly evolved Homoptera on broadleafed trees. The digestive systems of the higher aphids and scales are much more complex and are apparently evolved to a stage where they can use a larger and faster flow of sap. Dusting for ants appears to be hardly worth while in coniferous areas in the north. However the natives of eastern Tennessee say that the earliest bee honey crop of the spring comes from the "little bugs on the pine trees". Our bee experts, Professor W. E. Dunham and R. R. Reese, confirm this. Aphid honey dew is very local, more often found in the Allegheny Mountains, but is a nuisance dark honey about the large Green Lawn Cemetery of Columbus, Ohio, which is a great area of lovely and cherished conifers. Bee-keepers near the cemetery have had to abandon bee-keeping or move their hives to a greater distance.

The second limitation is the fact that this type of collecting catches only field workers, and of these usually exclusively one caste of a species, minors or majors. The character of males and queens and the structure of the nest are not found. For three summers we collected a minute dark ***rufa*** working on low bushes, milkweed and other herbaceous flora, one we supposed was an undescribed ***microgyna*** and could not find a nest Eventually we found its nest which on being opened proved to be the large *Formica rufa clivia* Creighton We had been collecting the minors all the time in nests of the majors but had been identifying the nests by the large red majors and ignoring the minors which operated by themselves on honey dew in pure groups of the minor caste. Enough has been said to indicate the basic necessity of collecting ants in long series from known ants. Otherwise ant taxonomy develops headaches. However dusting for ants in trees does uncover species which appear seldom to contact the ground and should not be overlooked Such collecting can be operated with the least over-all expense of time by a Hemipterist or other friend who by necessity does collect some type of tree insect. Ant faunas are at present so little known especially in areas unexplored for ants that the myrmecologist spends his time most profitably on ground and tree trunk forms.

4. *The Economic Entomologist and his light trap and bait.*—In Ohio we have added a genus and at least two species to the Ohio list from queens taken in light traps. Certain species of the *curvispinosus* group of ***Leptothorax*** have mating flights at night, when thousands of them will fly to a lighted sheet. In Ohio work was done with permanent light traps with a funnel and collecting bottle where ants were mixed with beetles and other trapped insects. We have forms of this group of ***Leptothorax*** and an undetermined species of ***Colobopsis***, rare this far north, taken in such light traps by Doctor C. R. Neiswander of the Wooster Experiment Station who was scouting the state for pests. Unfortunately the weak males fly less often to light. The catches are almost one hundred per cent queens.

The use of collectors interested in bush and tree insects *is obtained as a favor*. No collector can collect effectively for any length of time outside of his own group. He overlooks his own group. According to authorities on human behavior, a favor freely given *and accepted* calls for an equal favor in return. The writer saves all beetles for the Coleopterist. These can be preserved in one drahm vials of 70 per cent alcohol along with the ants, sorted out later and presented with proper gracious words and gestures. Such a tie-up between two collectors is well worth while and becomes increasingly profitable to each.

For the collector of Hemiptera for some reason the tie-up is less effective. The ant collector too often brings back widely spread common species.

A PRELIMINARY STUDY OF THE EFFECT OF DDT ON APHIS MAIDIS FITCH AND ITS INSECT ENEMIES WITH PARTICULAR REFERENCE TO APHIDIUS (LYSIPHLEBUS) TESTACEIPES (CRESS.)[1]

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The discovery of the "wonder killing powers" of DDT spurred economic entomology. A great deal of experimental work was undertaken to determine the toxicity of DDT to various economic pests. Often DDT surpassed any other method of control.

Irregularities occurred, however. In some specific instances observations have been made of huge populations of insects or mites being built up after DDT treatment. The cause of this irregularity was not known and the question arose: Is DDT more toxic to the natural enemies playing an important role in the checking of pests than to the pest itself? If this were true, the biological cycle might be radically upset resulting in a large increase in the pest population.

Unfortunately, the trend in insecticide study has been to ignore the beneficial insect. Little attention has been given to the effect of various insecticides on parasites, predators, or pollinators. With these things in mind, a comparative study which would involve both the host population and its natural enemies was undertaken. This paper reports the observations of such a study.

During the summer of 1945, heavy populations of the corn leaf aphid, *Aphis maidis* Fitch[2] were present on field corn near Columbus, Ohio. There was heavy parasitism of this aphid by a braconid parasite, *Aphidius (Lysiphlebus) testaceipes* (Cress.).[3] This aphid and parasite were used as test insects. Many other biological enemies of this aphid including coccinellids, chrysopids and syrphids were present, and when possible, their activities were noted.

BIOLOGY OF HOST AND PARASITE

The biology of the principal insects involved in experimental work is reviewed briefly.

Aphis maidis Fitch

To quote from ***Destructive and Useful Insects*** by Metcalf and Flint:

> "Own knowledge of the life history of this insect is incomplete. In the North Central States, it appears in the corn fields about midsummer. In the South the insect multiplies rapidly and does its greatest damage in the winter months. Of the females, only the winged and wingless ovoviviparous

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[1] From a thesis submitted to the Graduate School of the Ohio State University in partial fulfillment for the Degree of Master of Science, this paper reports studies made by the author while employed by the Bureau of Entomology and Plant Quarantine, Division of Truck Crops, Columbus, Ohio. Grateful acknowledgment is made to Dr. Neale F. Howard, in charge of the laboratory, and to Dr. Dwight M. DeLong, of the Ohio State University, for their kind assistance in making this study.

[2] Determined by P. W. Mason.

[3] Determined by C. F. W. Muesebeck.

forms are known. Males have been noted only very rarely and the egg-laying true females have never been found. No observations have been made on the winter stages in the northern states, and it is not known whether this species passes the winter in the egg stage in this section or whether it migrates up from the South during the spring and early summer. . . . The number of ovoviviparous generations produced in a year varies from about 9 in Central Illinois to as many as 50 in southern Texas. The insects feed until they are killed by a heavy frost, or the drying up of their food plants."

This insect prefers sorghums, but may be found on corn, barley, sugar cane, millet, broomcorn, Sudan grass and many other plants of the grass family.

The corn leaf aphid is destructive to corn by feeding on the tassel and silk and coating them with honey dew which seriously interferes with pollinization of corn. Also, great numbers of corn earworm moths may be attracted to the honey dew on the ears. When corn is infested by this insect, numerous greenish or greenish-blue aphids appear in the curl of the leaves or upper stalk; sometimes they may entirely cover the leaves.

Aphidius (Lysiphlebus) testaceipes (Cress.)

A. testaceipes (Cress.) was chosen for a specific study because of its very large numbers in the field. In many instances 100% parasitism of the aphid host occurred.

It has been found that the life cycle of this insect takes from 7 to 15 days in passing from egg to adult during August and September (Webster and Phillips, 1912). The females begin ovipositing under favorable conditions within a few hours after emerging from the host. The oviposition period lasts from three days to a week depending upon temperature. The females may live and oviposit for five or six days in warm weather. This parasite is not active at a temperature much below 56° F. Aphids begin to reproduce at a temperature at or slightly below 40° F., allowing considerable damage to be done during temperatures at which development of this parasite is retarded.

FIELD TESTING

METHODS—

A survey of corn fields showed the heaviest infestations of the corn leaf aphid to occur on the outside edges of each field. This suggests that the aphids came to the corn from some border weeds and gradually worked their way toward the middle of the corn planting.

Infested corn plants within the first few rows of the field were classified as having heavy, medium, or light infestations. Plants having heavy infestations were selected for treatment. Each treatment was replicated four times, and each plot consisted of one corn plant. The insecticides were applied with hand knapsack sprayers and dusters.

CAGES—

Cages were constructed and placed over the tassels or upper parts of the stalks after treatment. These cages were made of a fine mesh cheesecloth and constructed with sleeves at either end which were tied to the stalk. Cages used in field experiment 1 were constructed with a celluloid frame (see Cage 1, figure 1). In field experiment 2 the cage was simplified (Cage 2, figure 1). The celluloid frame was dispensed with and the cage was kept from collapsing by the pressure which the corn tassels exerted against the walls from within. Easier to construct, it proved to be as satisfactory as cage 1.

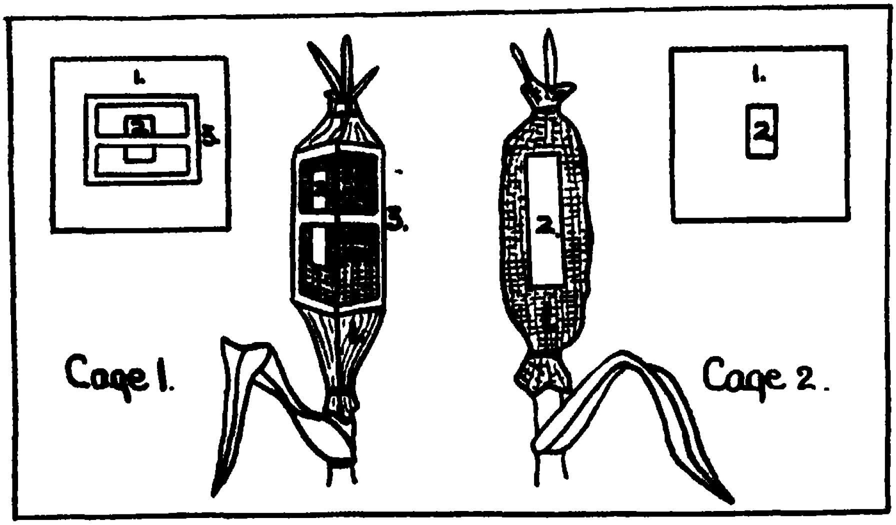


FIGURE 1. Construction of Cages, Field Experiments.
1 = cheesecloth covering, 2 = celluloid window, 3 = celluloid frame.

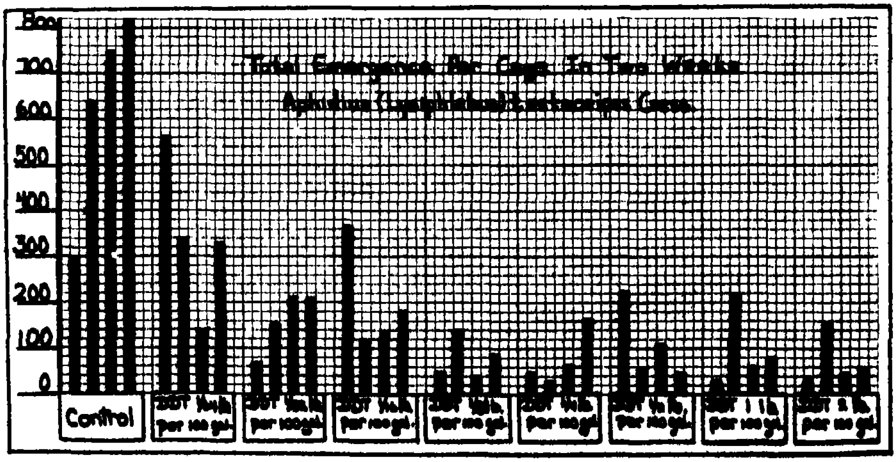


FIGURE 2. Parasite Emergence, Laboratory Experiment.
Histograms show total emergence for each cage (four cages per treatment).

INSECTICIDES—

For dosages used in each test, see Plates I, II, and III. Field experiment 1 was a test involving several formulae using different solvents. Field experiment 2 was based on concentrations of DDT from one formula using the same solvent.

The DDT (2, 2-bis (p.-chlorophenyl) −1, 1, 1-trichloroethane) used in suspension was received from the Geigy Company (G.N.B.A. mix 517) and consisted of 99.2% DDT. Stock formulae were prepared as follows and diluted to the desired concentrations:

DDT Benzol Formula:

DDT, 4 lb.; benzol, 1 gal.; B1956, ¼ pint.

DDT IDM #160 Formula:

This formula was received from R. D. Chisholm (Insecticide Division, Bureau of Entomology and Plant Quarantine), Moorestown, New Jersey. DDT, 1 lb.; Triton x 100, 1 lb.; Span 20 (sorbitan monolaurate—a product of Atlas Powder Company), 1 lb.; mix in enough acetone to make one gallon of stock solution.

DDT Kerosene Formula:

DDT, 5 parts; kerosene (commercial), 91 parts; B1956, 4 parts. On the dust plots, a Geigy 10% dust diluted in pyrophyllite was used.

For comparison with DDT, two other recommended aphicides were used.

(1) Nicotine-rotenone dust consisting of 1% rotenone to equal parts of sulfur and tobacco dust. (Bureau of Entomology and Plant Quarantine recommendation.)

(2) Black Leaf 40 at the rate of ¾ pound Black Leaf 40 per 100 gallons of spray.

DATA—

Aphid populations in the field were often so huge that they nearly overlapped covering every available space on a leaf, stalk or tassel. Due to the difficulty and lack of time and help to make actual counts, the investigator set up a scale, classifying the relative size of the population as very heavy, heavy, medium heavy, etc. Only living aphids were considered.

The parasite population was classified in the same manner with these exceptions. Both the number of adult parasites which had emerged and the number of parasitized aphids were considered.

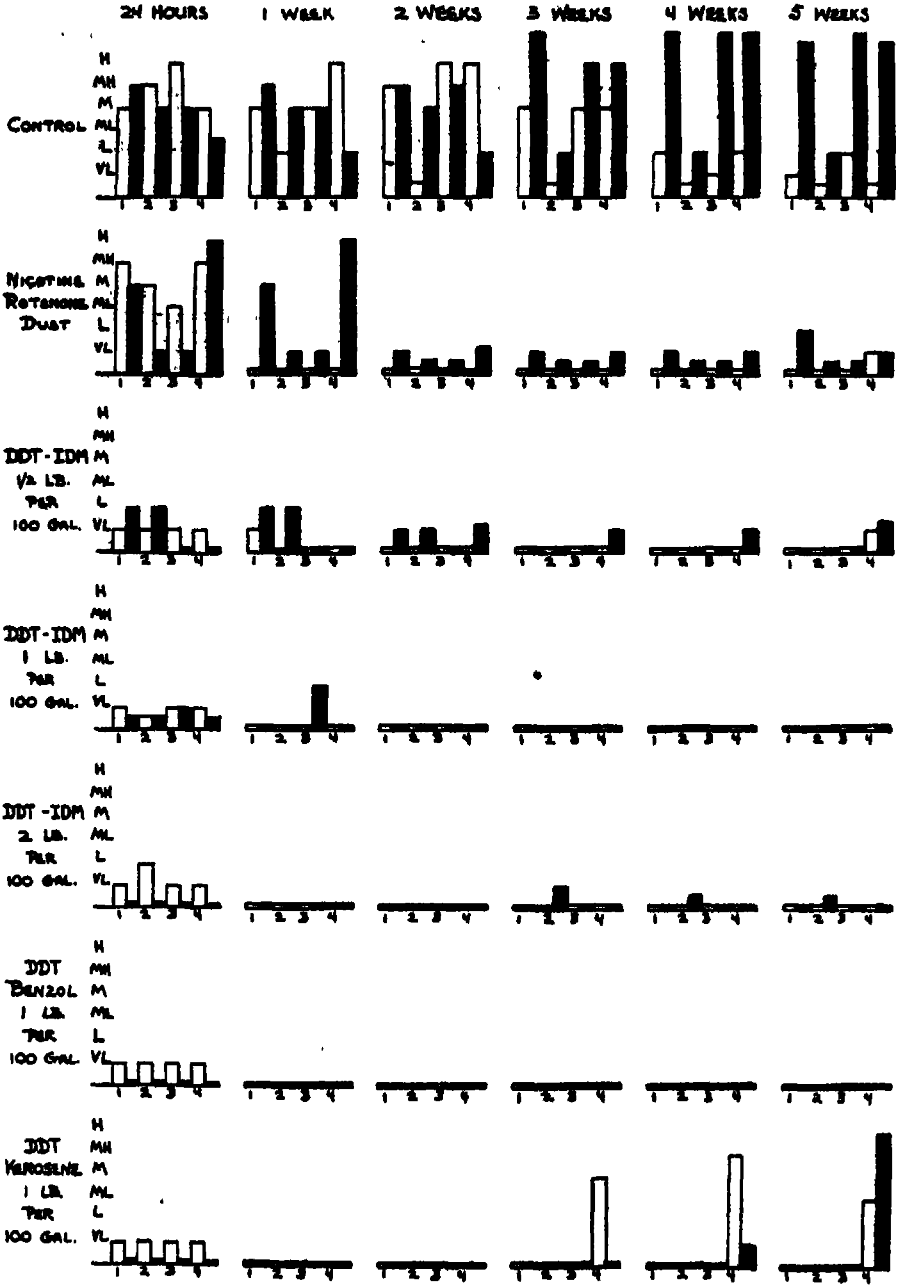
FIELD EXPERIMENT 1—

Data were recorded twenty-four hours after treatment and then once a week for a period of five weeks (see Plate I). The data plotted in the histograms on Plate I show that twenty-four hours after treatment both aphid and parasite populations of all DDT treated plots were greatly reduced. The control of the aphids at first appears better with DDT than with nicotine-rotenone dust. But, one week after treatment, the data show a disappearance of the aphid population on the nicotine-rotenone dust plots with the parasite population remaining higher than on any of the plots treated with DDT.

An irregularity appeared on #4 plot of the DDT-kerosene emulsion treatment. After the third week, the aphid population rose very rapidly. Those parasites which had not been exterminated by DDT staged a come-back that was noticeable the fourth week and was lowering the aphid population in the fifth week.

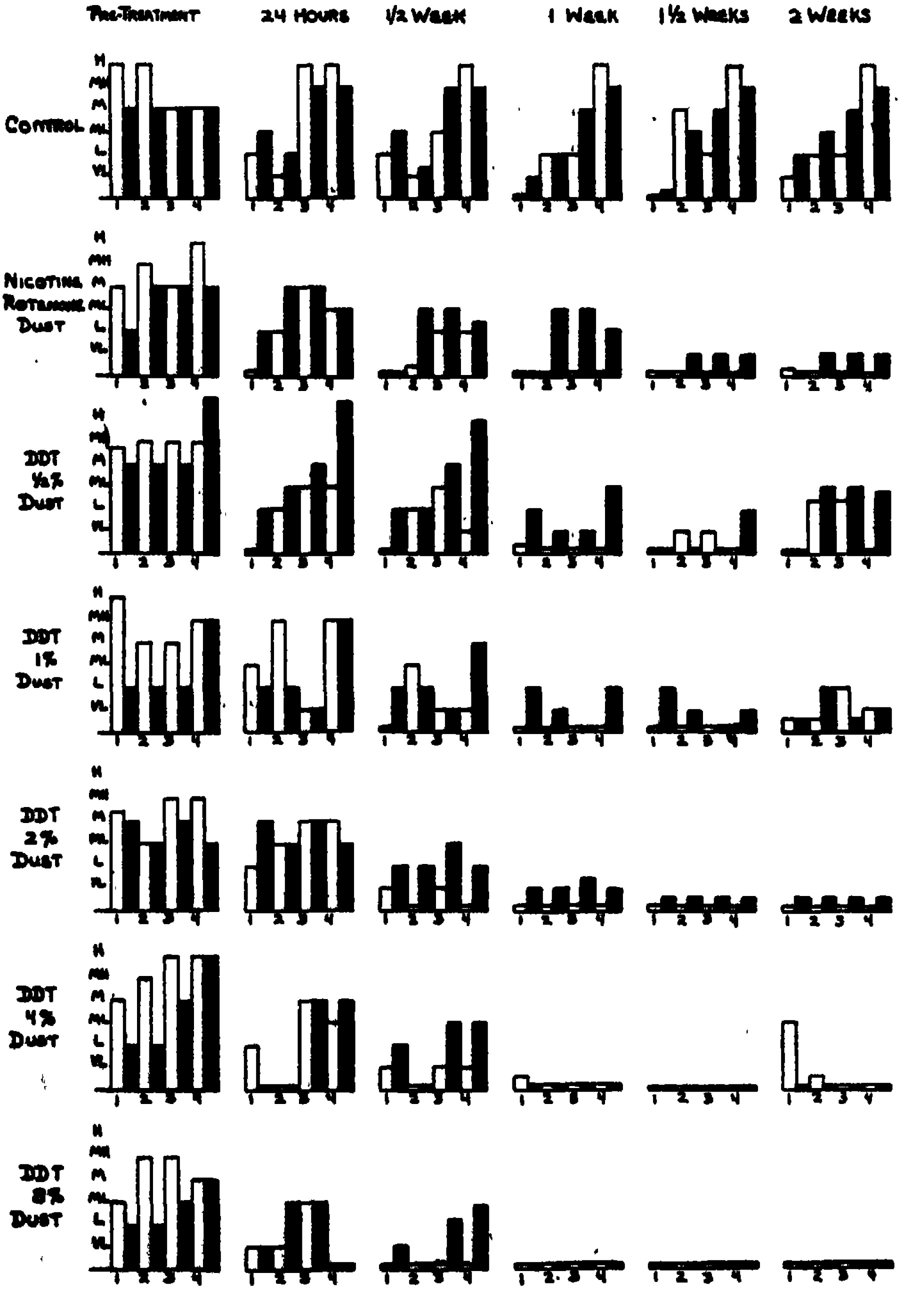
FIELD EXPERIMENT 2—

Data were recorded and analyzed in the same manner as in experiment #1 with slight variations. Observations were made twenty-four hours after treatment



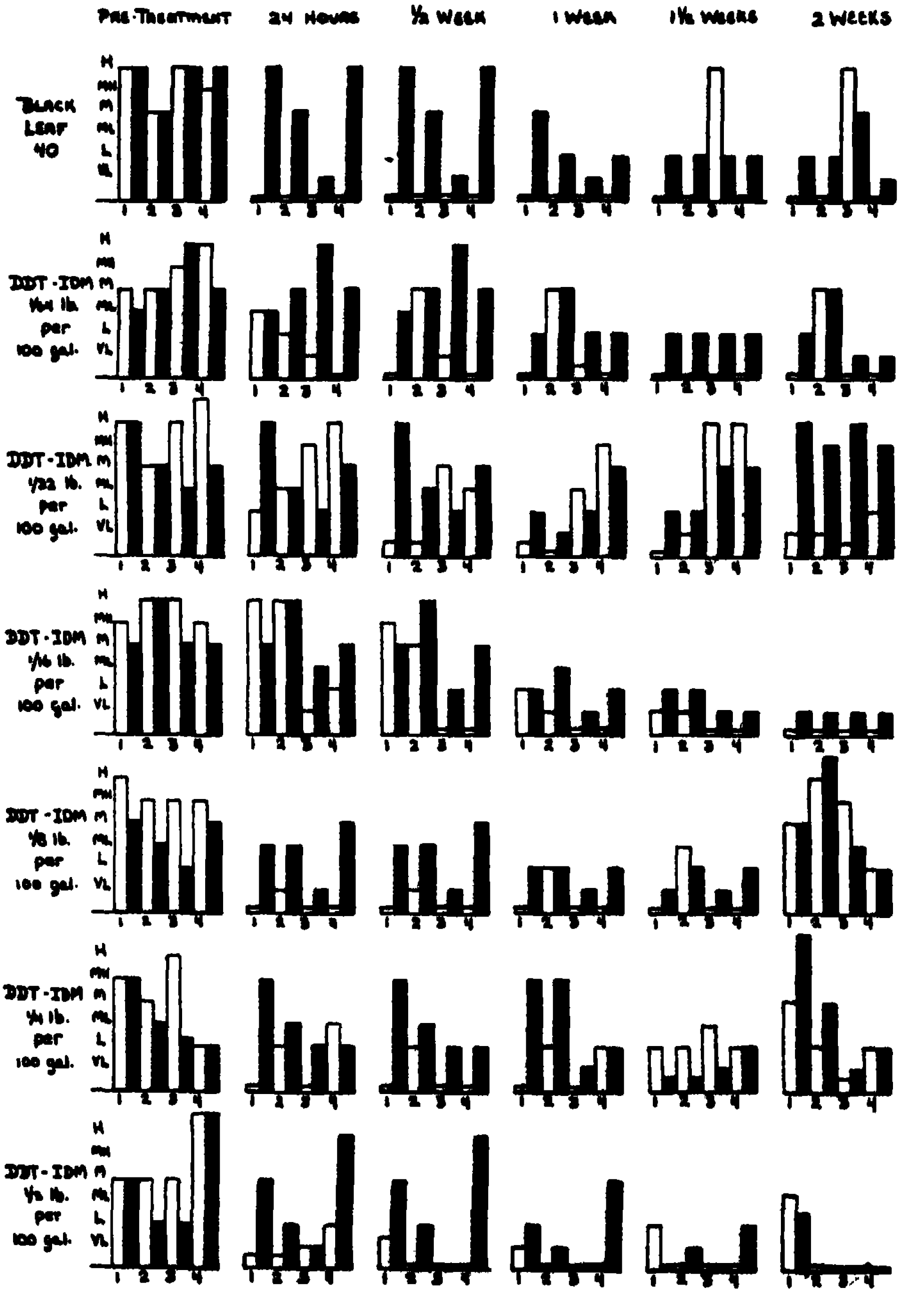
FIELD EXPERIMENT 1—PARASITE AND APHID POPULATIONS

Black = parasite, *A. testaceipes;* white = aphid, *A. maidis*. H = heavy, MH = medium heavy, M = medium, ML = medium low, L = low, VL = very low. Replicated plots are numbered 1, 2, 3, 4 for each treatment.



FIELD EXPERIMENT 2—DUST PLOTS, PARASITE AND APHID POPULATIONS

Black = parasite, *A. testaceipes;* white = aphid, *A. maidis.* H = heavy, MH = medium heavy, M = medium, ML = medium low, L = low, VL = very low. Replicated plots are numbered 1, 2, 3, 4 for each treatment.



FIELD EXPERIMENT 2—SPRAY PLOTS, PARASITE AND APHIS POPULATIONS

Black = parasite, *A. testaceipes*; white = aphid, *A. maidis*. H = heavy, MH = medium heavy, M = medium, ML = medium low, L = low, VL = very low. Replicated plots are numbered 1, 2, 3, 4 for each treatment.

and twice each week for a period of two weeks. This test was set up late in the season and due to corn harvest in mid-September, of necessity had to be terminated in two weeks.

In regard to the spray plots, Plate III illustrated good aphid control with Black Leaf 40. DDT treatments were at much lower concentrations than those of the previously mentioned experiment. Fair control appears to have been obtained with the highest concentration (½ pound DDT per 100 gallons of spray). In all cases, the parasites were not eradicated but rebuilt populations when the aphid population started to rise.

The dust plots illustrated on Plate II show that a 2% DDT dust and nicotine-rotenone dust were about equally effective aphicides. At concentrations below 2% the aphids reestablishing themselves commenced to rebuild their population. The 4% and especially the 8% dusts nearly eradicated both aphids and parasites within a week.

LABORATORY TESTING

METHODS—

The plan was to set up a laboratory test to resemble field conditions. Corn tassels heavily infested with the corn leaf aphid which were largely parasitized by the braconid, *A. testaceipes*, were located in the field. These were cut and taken to the laboratory. They were then trimmed to fit cages described below, implanted in a can of moist sand, and treated. A pressure type compressed air paint sprayer was used to cover all parts of the plant adequately with DDT. The dosages used are shown on Plate IV.

Four replicates, each consisting of one plant, were used for each treatment. The plants were kept under artificial lights to simulate natural conditions.

CAGES—

Cages were constructed of large celluloid strips which were rolled into cylinders and sealed with acetone making a cage eighteen inches high and six inches in diameter. A very fine mesh cheesecloth ceiling was fastened in the cage with acetone. The base consisted of an 8-inch clay flower pot saucer in which a layer of sand was placed.

DATA—

Regular inspection of the cages took place each day for a period of two weeks. An actual count of the number of live parasites was made along with a count of the number of dead parasites. Predators were present and their various stages of development were noted along with the aphid host. Figure 3 illustrates the total parasite emergence per cage.

APHIDS—

The aphids remained alive and in abundance on the checks for a week with the populations gradually decreasing after that time. Table I shows aphid kill 24 and 48 hours after treatment.

The decreasing size of the aphid population was probably due to adverse environmental conditions. While the experiment was in progress there was a sudden change in the weather. The days became very hot with an average temperature close to 80° F. The laboratory was not air-conditioned and the temperature could not be kept down to a more favorable constant for aphid development.

PARASITES—

Wherein the increase in temperature may have hindered aphid development its effect on the parasite population was the opposite. Parasites emerged in tremendous numbers and were very active.

For a record of the total parasites emerging from each cage see figure 4. The average number of parasites present each day during the period of two weeks has been plotted graphically (Plate IV). This series of graphs shows parasites emerging throughout the cages in all treatments. The lowest DDT concentration (1/64 lb. DDT/100 gal.) shows a decidedly lower parasite emergence than the control. But, the highest concentration (2 lb. DDT/100 gal.), although low, also shows continued emergence throughout most of the period.

TABLE I

APHID MORTALITY—LABORATORY DDT TESTS

TREATMENT	CAGE							
	24 hours				48 hours			
	A	*B*	*C*	*D*	*A*	*B*	*C*	*D*
1. Control	O	O	O	O	O	O	O	O
2. DDT 1/64 lb./100 gal	O	VL—	VL—	VL—	O	VL—	VL—	VL—
3. DDT 1/32 lb./100 gal	VL—	VL—	VL—	VL—	VL—	VL	VL—	VL—
4. DDT 1/16 lb./100 gal	VL—	VL—	VL—	VL—	VL—	VL—	VL—	VL—
5. DDT 1/8 lb./100 gal	VL—	VL—	VL—	VL—	VL—	VL—	VL—	VL—
6. DDT 1/4 lb./100 gal	VL—	VL—	VL—	VL—	VL	VL	VL	VL
7. DDT 1/2 lb./100 gal	M	L	MH	M	M	ML	MH	M
8. DDT 1 lb./100 gal	M	H	H	M	MH	H	H	MH
9. DDT 2 lb./100 gal	H	H	H	H	VH	VH	H	VH

A, B, C, D=Cage replicate; O=Zero, VL=Very low, L=Low, ML=Medium low, M=Medium, MH=Medium heavy, H=Heavy, VH=Very heavy mortality, VL— =Less than VL.

It seems quite significant that a similar curve for all treatments should be shown by this series of graphs. The emergence reaches a peak and declines, falling down very low and then commences to rise again and reaches another peak in 6 to 7 days. From these comparisons and the fact that this parasite may complete its life cycle in 7–15 days (Webster and Phillips, 1912), it seems logical that the parasites surviving treatment were able to mate and oviposit with the resulting offspring emerging as adults at the time of the second peak shown on the graphs.

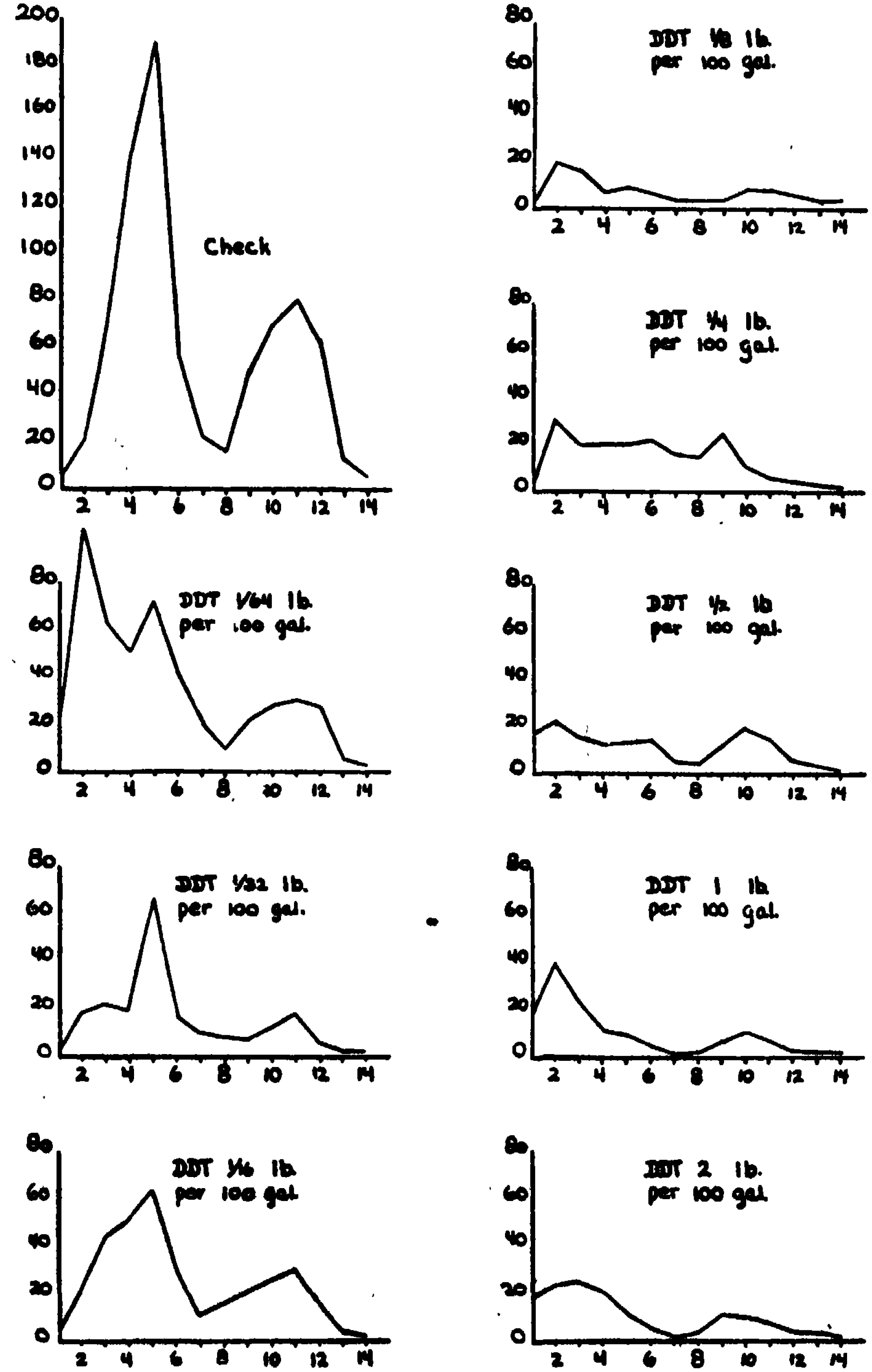
Certain paralytic actions were noted to occur to some of the parasites in cages treated with concentrations of one-fourth pound of DDT per hundred gallons and higher. Parasites would emerge, fly around, and as the data on Plate IV indicates, some would mate and oviposit. Others, as they walked on DDT treated leaves developed nervous reactions characterized by acute twitching of the legs and a gradual loss of equilibrium.

The number of moribund adult parasites increased rapidly in the higher concentrations of DDT. Parasites observed soon after emergence appeared normal until they had walked on the treated surface of the leaves for a short time.

PREDATORS—

In at least one cage of each treatment (concentrations of one pound of DDT per 100 gallons of spray and under) examples of the following occurred.

1. Coccinellid larvae pupated and emerged as adults.



LABORATORY EXPERIMENT

Comparison of Parasite Emergence. The average total living parasites present in the four cages for each treatment is plotted per day as the ordinate; the days being the abcissa.

2. In one cage (DDT ⅛ lb./100 gal.) 5 coccinellid pupae emerged as adults. One pair was observed mating, and eggs were laid.
3. Aphis lions emerged as adult lacewings.
4. Syrphid larvae pupated and emerged as flies.

These observations were only scattered occurrences throughout the cages; consequently, significant conclusions cannot be drawn from them.

SUMMARY

The biology of the corn leaf aphid, *Aphis maidis*, and its parasite, *Aphidius testaceipes*, is briefly reviewed. Field and laboratory experiments are reported of aphid infested field corn plants treated with DDT.

Population studies were made of the aphid and its parasite. A few observations on predators are listed.

In field tests, data taken 24 hours after treatment showed that DDT sprays were more effective against the corn leaf aphid than a nicotine-rotenone dust. One week after treatment nicotine-rotenone dust plots showed the same relative number of aphids killed as did DDT plots, but a lower relative number of parasites killed. One treatment of DDT did not eradicate the parasites unless the aphids were eliminated.

Further observations indicated that:

(1) *A testaceipes* was susceptible to DDT at the lowest concentration used (1/64 pounds DDT per 100 gallons).

(2) *A. testaceipes* was not eradicated at the highest concentrations used (2 pounds DDT per 100 gallons) but emergence was greatly reduced.

(3) Laboratory experiments with *A. testaceipes* showed a similar emergence curve for all treatments. The parasite emergence reached a peak, declined nearly to zero and then rose to another peak in six to seven days. This parasite may complete a life cycle in six to seven days. This indicates that parasites surviving DDT treatment, emerged as adults, mated, and oviposited in DDT treated aphids. The resulting offspring of the parasites were able to complete another cycle.

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A PROGRESS REPORT OF THE CREEL CENSUS AT LAKES ST. MARYS AND LORAMIE, OHIO, 1946

CLARENCE F. CLARK,[1] E. DEAN NOW,[2] JOHN FLINN[2]

INTRODUCTION

To manage anything properly, and to check progress, it is necessary to make inventories and to keep records of the turn-over of the products. Business-like methods to check progress must be applied to fisheries management so that errors in methods may be eliminated and possible mis-spent dollars can be saved. Over 70 years ago, Ohio began her first efforts toward conserving or protecting her fisheries resources. Yet, it was not until the spring of 1946 that a program was inaugurated to obtain some facts on fish taken by the anglers at Lakes St. Marys and Loramie. It is impossible to state with any degree of accuracy what returns have been derived from past conservation practices or what practices should be continued, because we have no past records of the crop harvested.

The Creel Census project at these lakes was a part of a state-wide program to place management on a business-like basis and to learn something about the effectiveness of legal lengths, bag limits and closed seasons. Legal lengths, bag limits, and closed seasons were removed from these lakes in preparation for the Creel Census.

METHODS OF TAKING THE CENSUS

The census at both lakes was made by men employed especially for that purpose. Their work was supplemented by my help on holidays and Sundays. These Creel Census Takers were provided with prepared cards for recording the data, equipment for measuring and weighing the fish, for taking air and water temperatures, and for measuring transparency of the water. The censuses started on March 31 at Lake St. Marys and May 5 at Lake Loramie. Both censuses terminated on September 30, 1946. The census was conducted from 8:30 A. M. to 5:30 P. M. except on days when greater concentrations of fishermen occurred. On these days, the census was conducted from 8:00 A. M. until 7:00 P. M. Census returns were obtained for six days of the week, Fridays excepted, at Lake St. Marys and Tuesdays at Lake Loramie.

No attempts were made to contact the entire public. The Creel Census Taker at Lake St. Marys made one complete round of the lake daily, by auto, to visit all landings and areas at which fishermen concentrate. His contacts were random samples of all areas visited. At Lake Loramie, the Creel Census Taker confined the major portion of his activities to the lower end of the lake where most of the anglers are found. He traveled by boat. One trip was made each day, by auto, to the upper end of the lake to check anglers in that area.

The lengths of the fish were recorded to the nearest half inch and the weights of a majority of the specimens were determined by means of a Hansin scale and recorded in grams.

Information such as wind direction, wave action, air and water temperatures, transparencies, and type of weather were recorded daily.

Fishermen cooperation was solicited and creel census boxes, containing the necessary equipment for recording data, were provided at strategic points around the lake. Our results from voluntary returns were comparable to those obtained by Needham (Copeia No. 1, 1937) and described by him as, "very incomplete." No data from voluntary returns is included in this report.

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PHYSIOGRAPHY

Lake St. Marys: Lake St. Marys lies in the eastern part of Mercer and the western part of Auglaize Counties, Ohio. It is an artificial body of water, 100 years of age, impounded by damming tributary streams of the St. Marys and Wabash Rivers and flooding the dividing area between them. The lake covers possibly 11,000 acres and is approximately 9 miles long and 4 miles wide in its greatest dimensions. The drainage area is approximately 72,640 surface acres (Sherman 1932: 132), including the lake itself. Howe (1902: 293) credited the lake with having an average depth of 10 feet, when first constructed; but it seems that erosion of shores and incoming silt have greatly reduced the average depth. The shoreline is rather regular and partially wooded with the major portion of the woodlands on the south side. The shallow water of the south side is chiefly a cat-tail marsh. Clay banks and sand beaches are characteristic of the north shore. The bottom is predominately blue-grey silt with patches of sand and gravel along the shoreline.

The lake lies in an East-West axis and is fully exposed to the prevailing southwest winds. "Wind" seiches, causing a 12-inch rise in the water level at the east end of the lake have been observed. Heavy wave action churns the water thus causing considerable variation in the transparency during the same day. Heavy wave action also prevents the use of the greater portion of the lake for many days during the fishing season. During the 1946 season, the water level fell 30 inches below the spillway level, due to lack of rainfall and normal evaporation.

Lake Loramie: Lake Loramie lies in the northwestern part of Shelby County. It was formed nearly 100 years ago by damming Loramie Creek. The lake has a surface acreage of approximately 1500 acres. It is approximately 5 miles long and 2 miles wide in its greatest dimensions. The drainage area is approximately 69,120 acres in extent. No accurate data is available on the depth but it probably would not exceed an average of 5 feet. The shoreline is rather regular but greatly altered in appearance by the emergent vegetation. Large areas are filled with American Lotus (*Nelumbo lutea* (Willd.) Pers.) and long stretches of the shallow waters are filled with willows (*Salix* spp.). In general, the immediate shoreline is timbered; although the drainage area is in a high state of cultivation. The bottom is composed largely of a soft blue-grey silt-like soil with considerable sand and gravel along the shore of exposed areas.

The lake lies in a Northeast-Southwest axis and is thus exposed to the prevailing southwest winds. However, due to the small size of the lake and its well wooded shoreline, the wave action, at few times, is dangerous for boating. The large drainage area, compared to the small size of the lake itself, results in rapid and numerous changes in water level and turbidity.

ANALYSIS OF DATA

Fishermen Contacted: Creel census returns were obtained for a total of 7,740 fishermen at Lake St. Marys and 5,277 at Lake Loramie. This represents an average of 49.9 anglers contacted per day at Lake St. Marys and 34.5 per day at Lake Loramie. The most popular fishing months were May at Lake St. Marys and June at Lake Loramie. Approximately 31% of the fishermen who fished these lakes were present during these months. At both lakes the number of anglers gradually declined throughout the season. Anglers from 52 counties in Ohio, 5 other states and one foreign country were contacted at Lake St. Marys and anglers from 29 counties of Ohio and two other states at Lake Loramie. Approximately 31% of the anglers contacted at Lake St. Marys came from the counties in which the lake lies. At Lake Loramie, only 15.8% of the anglers came from Shelby County.

Hours Fished: Due to the large size of each lake it was impossible for one Creel Census Taker to contact the anglers at the end of their fishing day. The Census Takers, therefore, contacted fishermen in the act of fishing as well as those who had completed their day's fishing. The 7,840 anglers at Lake St. Marys had fished for a total of 21,937.37 hours or an average of 2.8 hours per individual. The 5,277 anglers at Lake Loramie fished a total of 16,358.7 hours or an average of 3.1 hours per individual. Yet, our records of those anglers who had completed their day's fishing show an average of 3.5 hours at Lake St. Marys and 3.7 hours at Lake Loramie. It is upon the average hours fished by those anglers who had completed their day's fishing that the following data has been based.

Catch: The anglers contacted at Lake St. Marys took 21,758 fish or an average of 2.77 fish per angler at the rate of .99 fish per hour of fishing. The fishermen contacted at Lake Loramie caught 10,119 fish or an average of 1.93 fish per angler at the rate of .65 fish per hour of fishing. The catch was composed of eleven species at Lake St. Marys and ten at Lake Loramie. Crappies, *Pomoxis annularis* Raf. and *nigo-maculatus* (Le Sueer'), comprised the greater percentage of the fish taken at both lakes. The number of fish caught per hour of fishing was greatest in the month of September at Lake Loramie. It was almost identical for the months of June, July, and August at Lake St. Marys. On the basis of fish caught per hour of fishing, May was the least productive month at Lake Loramie and April at Lake St. Marys. Yet, these months ranked second in the number of anglers fishing at the respective lakes. At Lake St. Marys, 64% of the anglers contacted caught no fish and only 1.47% took more than the bag limit in force at other state waters. At Lake Loramie 34% of the anglers caught no fish and 9% took more than the bag limits effective at other state waters.

Crappies: At both lakes, crappies represented the major portion of the catch, 64.7% at Lake St. Marys and 40% at Lake Loramie. Crappie fishing began in late March at Lake St. Marys but not until early May at Lake Loramie. Crappie fishing was best at Lake Loramie during the week of June 10 to 16, but at Lake St. Marys became gradually better until it reached its peak in the middle of August. Crappies were again taken in increasingly greater numbers during September. The average length of the crappies checked at Lake St. Marys was 5.8 inches and weighed 1½ ounces. The average size of these checked at Lake Loramie was 6½ inches in length with a weight of 2½ ounces. Approximately 23% of the Lake Loramie crappies were over 7 inches in length but only 2.25% of those from Lake St. Marys were over 7 inches in length.

Bluegills—Lepomis machrochirus Raf.: Bluegills made up nearly 26% of the total catch at Lake Loramie but comprised only 2.69% at Lake St. Marys. Bluegill fishing reached its peak at both lakes during the latter part of June, and then dropped off during July and early August. Increasingly greater numbers of bluegills were taken at both lakes during the last few weeks of the census. The bluegills at Lake Loramie averaged 6½ inches in length and 2½ ounces in weight as compared with an average length of 5.55 inches and 2 ounces in weight at Lake St. Marys.

Bullheads—Ameiurus melas melas (Raf.) and *A. nebulosus nebulosus* (Le Sueur): Bullheads ranked third in number of fish caught at both lakes. They represented nearly 20% of the harvest at Lake Loramie and approximately 8.1% at Lake St. Marys. Most of the bullheads were brown bullheads locally known as "marble catfish." Bullhead fishing at Lake St. Marys was best in April and gradually but steadily decreased until the end of the census. At Lake Loramie, bullhead fishing improved steadily each month until it reached its peak in the middle of September. The average size of the bullheads caught at both lakes was approximately 8¾ inches; but those from Lake Loramie weighed 5¾ ounces as compared with an average of 4¼ ounces at Lake St. Marys.

Channel Catfish—Ictalurus lacustris (Walbaum): "Channels" ranked second in importance in the anglers catch at Lake St. Marys, comprising 19.86% of the total catch, but represented only 2.7% of the total catch at Lake Loramie. Channel catfish fishing at Lake St. Marys was best during June, but best in September at Lake Loramie. The average channel catfish checked at Lake St. Marys was 10¾ inches long and weighed 12 ounces as compared to an average length of 11¼ inches and 17 ounces at Lake Loramie.

Largemouth Black Bass—Huro salmoides (Lacepede): Approximately 3.26% of the fish caught at Lake Loramie were largemouth bass but only 1.18% of those taken at Lake St. Marys were of this species. Bass fishing was fairly consistent throughout the season. In spite of the lack of legal lengths and bag limits, the sportsmen returned to the lake 7.77% of the bass taken at Lake St. Marys and 5.39% of those taken at Lake Loramie. The bass creeled by the anglers ranged from 6½ inches in length to 21½ inches at Lake Loramie and 24 inches at Lake St. Marys. The average bass at Lake St. Marys was 14.6 inches in length and weighed 2 pounds and 14 ounces as compared with the average of 12 inches and 18 ounces at Lake Loramie.

TABLE I

COMPARISON OF LAKES ON BASIS OF FISH CAUGHT PER HOUR OF FISHING

WATER AREA	STATE	FISH PER HOUR	DATE OF CENSUS	AUTHORITY
Mirror Lake	Mich.	3.3	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Doyle Lake	Mich.	2.8	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Walsh Lake	Mich.	2.6	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Crooked Lake	Mich.	2.5	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Cedar Lake	Mich.	2.2	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Cassidy Lake	Mich.	2.0	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Greene Lake	Mich.	1.7	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Waubesa Lake	Wis.	1.53	May 15-Sept. 25, 1939	(Frey & Vike 1941: 340)
Mill Lake	Mich.	1.2	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Fife Lake	Mich.	1.07	June 25-Sept. 30, 1934	(Eschmeyer 1939: 355)
Fife Lake	Mich.	1.0	June 25-Sept. 30, 1936	(Eschmeyer 1939: 355)
Fife Lake	Mich.	1.0	June 25-Sept. 30, 1937	(Eschmeyer 1939: 355)
Clear Lake	Mich	1.0	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Lake St. Marys	Ohio	0.99	Mar. 31-Sept. 30, 1946	
Portage Lake	Mich.	0.9	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Sugarloaf Lake	Mich.	0.9	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Kegonsa Lake	Wis.	0.82	May 15-Sept. 25, 1939	(Frey & Vike 1941: 340)
Lake Loramie	Ohio	0.65	May 5-Sept. 30, 1946	
Chautauqua Lake	N. Y.	0.55	....	(Moore 1937:)
Mud Lake	Mich.	0.5	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Waterloo Mill	Mich.	0.4	June 25-Nov. 30, 1936	(Hazzard & Eschmeyer 1938: 638)
Foots Pond	Ind.	0.28	June 25-Aug. 22, 1940	(Lagler & Lagler 1942: 112)

DISCUSSION

It is interesting to note that the counties, in which Lakes Loramie and St. Marys lie, supplied only a small percentage of the anglers contacted during the census. Montgomery County supplied the greatest number of anglers at Lake Loramie and ranked second at Lake St. Marys. The fact that 5% of the anglers contacted at Lake St. Marys were from other states does not speak ill of Ohio fishing.

The small size of Lake Loramie, and the concentration of the anglers at the lower end of the lake, enabled the Creel Census Taker to make a fairly accurate estimate of the daily total number of anglers using the lake. Practically all the anglers could be counted by cruising around the lower end of the lake. All areas were visited at least three times per day.

The Creel Census Taker at Lake St. Marys estimated the number of anglers at each fishing area as he made his daily trip around the lake. Due to the fact that the average fishing time per angler was 3.5 hours, the Creel Census Taker could not have observed over one-third of the anglers fishing at any given point during the day. For this reason, his estimates have been multiplied by three to obtain the total number of anglers using the lake per day.

It is estimated that 136,311 or 13 anglers per acre of water, fished Lake St. Marys during the period of the census and that 17,701 or 12 anglers per acre of water fished Lake Loramie. Approximately 85% of the anglers at Lake St. Marys and 71% at Lake Loramie fished from the shore.

When compared on the basis of fish caught per hour of fishing, with other creel census reports, we find Lake St. Marys to be about average and Lake Loramie to rank rather low. (see table I)

The average number of fish caught per hour of fishing for the above 22 bodies of water is 1.26 or .3 above Lake St. Marys and nearly double that of Lake Loramie.

The estimated 136,311 anglers at Lake St. Marys fished a total of 377,088.5 hours. At .99 fish per hour of fishing, the anglers removed 472,317 fish from the lake during the period of the census. An idea as to the poundage of the fish caught is given by the following table.

TABLE II

FISH HARVEST AT LAKE ST. MARYS DURING THE PERIOD OF THE CENSUS

SPECIES	PER CENT OF TOTAL	TOTAL NUMBER	AVERAGE WEIGHT, OUNCES	TOTAL WEIGHT, POUNDS	POUNDS PER ACRE
Crappies	64.64	305,352.9	1.5 oz.	28,626.2	2.66
Channel Catfish	19.86	93,802.15	12 oz.	70,351.61	6 39
Bullheads	8 09	38,210.44	4.5 oz.	10,746.68	98
Bluegills	2.69	12,705.33	2.0 oz.	1,588.29	14
Largemouth Bass	1 18	5,573.34	46 oz.	16,023.35	1.45
Carp	2.76	13,035.95	13 oz.	10,597.96	.96
	99 22%	468,680.15		137,934.09	12 58

The estimated 17,701 anglers fishing at Lake Loramie fished 65,494 hours. At .65 fish per hour of fishing, they caught 42,591 fish during the period of the census. An idea as to the poundage may be obtained from the following table.

TABLE III

FISH HARVESTED AT LAKE LORAMIE DURING THE PERIOD OF THE CENSUS

SPECIES	PER CENT OF TOTAL	TOTAL NUMBER	AVERAGE WEIGHT, OUNCES	TOTAL WEIGHT, POUNDS	POUNDS PER ACRE
Crappies	39.93	17,007	2.5 oz.	2,657.3	1.78
Bluegills	25.9	10,971	3 oz.	2,057.1	1.37
Bullheads	20.14	8,578	5.7 oz.	3,055.9	2.04
Largemouth Bass	3.26	1,388	18 oz.	1,562.	1.04
Channel Catfish	2.71	1,194	14 oz.	1,044.9	.69
	91.94	41,136		10,377.2	6.92

When Lakes Loramie and St. Marys are compared to other bodies of water on the basis of pounds of fish caught per acre, we find they compare favorably with all but the well managed lakes checked by the Illinois Natural History Survey. The following compares the harvest in pounds per acre as shown by Creel Census reports on widely scattered bodies of water in the Middle West.

WATER AREA	STATE	POUNDS PER ACRE	AUTHORITY
Fork Lake	Illinois	162	(Bennett, Thompson & Parr)
Unnamed Lake	Illinois	98	(Thompson 1941: 211–212)
Unnamed Lake	Illinois	80	(Thompson 1941: 211–212)
Shoe Lake	Indiana	46	(Ricker 1942: 223)
Muskellunge Lake	Indiana	27.5	(Ricker 1945: 343)
Eight Crow Wing Lake	Minnesota	19.1	(Eddy 1941: 39)
Waukesa Lake	Wisconsin	13 5	(Frey & Vike 1941: 344)
Lake St. Marys	Ohio	12.58	
Yellowwood Lake	Indiana	10.0	(Ricker 1945: 343)
Fife Lake	Michigan	10.0	(Eschmeyer 1936: 222)
Richter Lake	Wisconsin	8.6	(Elkins 1937: 307–312)
Lake Loramie	Ohio	6.9	
Delta Lake	Wisconsin	4.6	(Elkins 1937: 306–312)
Anderson Lake	Wisconsin	3.9	(Elkins 1937: 306–312)
Pike and Round Lakes	Wisconsin	2.8	(Elkins 1937: 306–312)
Deer Lake	Minnesota	2.64	(Eddy 1941: 39)
Island Lake	Minnesota	2.56	(Eddy 1941: 39)

The lack of fishing intensity accounts to a great extent for the small number of pounds of fish removed per acre from Lakes St. Marys and Loramie. If the shore fishermen at Lake St. Marys fished a strip 100 feet wide around the entire shoreline, there would remain over 10,000 acres of water to be fished from the 1,598 boats on the lake. This means 1 boat to approximately 7 acres of water. At Lake Loramie approximately 500 boat licenses were sold in 1946 or 1 boat to each 3 acres of water of the lake.

Fish have been stocked annually in Lakes St. Marys and Loramie as a part of Ohio's fisheries conservation program. A comparison of the following tables depict the correlation between stocking and the harvest.

LAKE ST. MARYS

Species	*Percentage of Fish Stocked*	*Percentage of Fish Caught*
Bluegills	58.61%	2.69%
Bullheads	25.04%	8.09%
Largemouth Bass	5.74%	1.18%
Crappies	4.43%	64.64%
Channel Catfish	3.77%	19.86%

LAKE LORAMIE

Species	*Percentage of Fish Stocked*	*Percentage of Fish Caught*
Bluegills	59.81%	25.9 %
Bullheads	28.04%	20.1 %
Largemouth Bass	4.32%	3.26%
Crappies	2.82%	39.93%
Channel Catfish	2.55%	2.71%
Perch	1.72%	0.

From the above tables it might appear that stocking is somewhat correlated with the fish harvest at Lake Loramie, but has no correlation with the harvest at Lake St. Marys. Yet, over one-third of all the fish taken at Lake Loramie and nearly two-thirds of those taken at Lake St. Marys were crappies in spite of the fact that this species comprised less than 5% of the fish stocked. Only one crappie was stocked to 14 bluegills at Lake St. Marys but 30 times as many crappies as bluegills were caught. Approximately 2% of the fish stocked in Lake Loramie were perch but none were observed during the census. At both lakes the take of carp exceeded 1% of the total catch but none have been stocked according to the records of the Ohio Division of Conservation and Natural Resources. According to the "old-timers," who commercially fished Lakes Loramie and St. Marys, there was a time when few crappies were found in these lakes. Had crappies been stocked at the time of their increase, these plantings would have received credit for their increase in numbers. A lack of stocking over a period of 10 years shows no decrease in the numbers of crappies in either lake. The elimination of all stocking from these waters for a period of years is needed to provide necessary "clincher" data on the efforts of stocking.

Test nets were operated in each lake in April, June, and August. In spite of relaxed regulations, the test nets took 31 fish per hour exclusive of the shad, at Lake Loramie and 44 at Lake St. Marys.

SUMMARY AND CONCLUSIONS

1. A Creel Census was conducted at Lake St. Marys from March 31 to September 30, 1946, and at Lake Loramie from May 5 to September 30, 1946.
2. Anglers averaged catching .99 fish per hour of fishing at Lake St. Marys and .65 fish per hour at Lake Loramie.
3. When compared on the basis of fish caught per hour of fishing, with other lakes in the Middle West, St. Marys ranks about average but Lake Loramie is low in production.
4. An estimated 477,088 hours of fishing at Lake St. Marys yielded 472,317 fish weighing 137,934 pounds or 12.58 pounds per surface acre of water.
5. An estimated 17,701 anglers at Lake Loramie fished 65,493.7 hours and caught 42,591 fish weighing 10,384.8 pounds or approximately 7 pounds per surface acre of water.
6. The catch per hour had no correlation with the number of anglers fishing.
7. Although some apparent correlation between stocking and harvest may be noted at Lake Loramie, the species taken in greatest numbers (crappies) is one stocked in smallest numbers.
8. No correlation can be seen between the catch and stocking at Lake St. Marys.
9. In spite of bluegills being stocked in great numbers at both lakes, crappies are the dominant fish.
10. Only 1.47% of the anglers at Lake St. Marys and 9% of those at Lake Loramie caught over the bag limits in force at other state waters.
11. A bag limit at Lake St. Marys would have affected only one in each 67 anglers and one in 10 at Lake Loramie.
12. Legal lengths on crappies at Lake St. Marys during the summer of 1946 would have prevented the taking of the average size crappies (5.8 inches) or practically closed fishing for the season.
13. A large catch of breeder fish at both lakes in test nets, together with the small catch per acre by the anglers, indicates a large population of breeders remaining after a season of relaxed regulations.

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SOME EFFECTS OF PLANT GROWTH-REGULATING SUBSTANCES ON MICROORGANISMS

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During recent years, much work has been done on the effect of various synthetic plant hormones on higher plants. This suggested that the same compounds may also have some effects on lower forms of living organisms—the bacteria, yeasts, molds, and actinomycetes.

Little work has been reported on the effects of these compounds on microorganisms. Indole acetic acid was found by Leonian and Lilly (1937) to be inhibitory to several fungi and algae. Brannon and Bartsch (1939), however, tested the effect of several of the growth regulators on *Chlorella vulgaris* and found marked stimulation when the chemicals were used in low concentrations.

Stevenson and Mitchell (1945) reported that 0.02 per cent of 2-4-dichlorophenoxy acetic acid or its sodium salt inhibited, and 0.1 per cent prevented, the growth of several species of bacteria; molds, however, were much more tolerant to the chemical. Culler (1946) in general confirmed these results and further noted greater susceptibility of gram-positive than of gram-negative bacteria.

The investigation reported in this paper was undertaken to increase our knowledge of the effects of a few plant growth-regulating substances on several bacteria and on a few molds and actinomycetes.

METHODS AND MATERIALS

Chemicals used.—The sodium salts of 2-4-dichlorophenoxy acetic acid, β-naphthoxy acetic acid, 4-chlorophenoxy acetic acid, and β-indole butyric acid were used in the experiments.

These were prepared by suspending the weighed acid in water, and titrating with N/1 NaOH using phenolphthalein as the indicator.

Serial dilutions were prepared in 0.05 molar phosphate buffer with pH 6.2. Resulting concentrations ranged from 0.00001 to 1.0 per cent.

TEST ORGANISMS

BACTERIA

Aerobacter aerogenes
Aerobacter cloacae
Bacillus subtilis
Brucella abortus
Corynebacterium diphtheriae
Escherichia coli
Sarcina lutea
Serratia indica
Serratia marcescens
Staphylococcus aureus

MOLDS

Aspergillus niger
Mucor sp.
Penicillium notatum

ACTINOMYCETES

Streptomyces griseus
Streptomyces lavendulae

Tests of growth.—Growth on plates was tested using the ratio of 90 ml. agar basal medium to 10 ml. of salt solution. Difco nutrient agar was used for *B. subtilis*, *A. cloacae*, *S. lutea*, *S. aurens*, *S. indica*, and *S. marcescens*. Tryptose-glucose agar was used to test the growth of *B. abortus*, *C. diphtheriae*, *S. aureus*, and *E. coli*. Difco malt agar was prepared for testing *P. notatum*, *A. niger*, and *Mucor* sp. Glucose-asparagine agar was used for *S. griseus* and *S. lavendulae*.

Tests for turbidity were set up as follows. Nine ml. amounts of broth were pipetted into standard 7″ x ⅞″ test tubes. To these were added 1 ml. amounts of the various dilutions of the plant growth-regulating substances. Difco nutrient broth was used as the basal medium in testing *S. lutea*, *B. subtilis*, *S. aureus*, and *E. coli*. Tryptose-glucose broth was employed in testing growth on *B. abortus*, *C. diphtheriae*, *S. aureus*, and *E. coli*.

The tubes were inoculated with 0.2 ml. of a broth suspension of the organisms and incubated at 37° C. for 90 hours. The amount of growth as shown by turbidity was determined by obtaining galvanometer readings, using an Evelyn Photoelectric colorimeter, at various time intervals throughout the incubation period. Light filter #540 was used. The photometric densities were then calculated from the galvanometer readings.

Biochemical tests.—Biochemical tests were made using nutrient gelatin, and glucose, sucrose, lactose, tryptone, and M.R.V.P. broths. These media were prepared to have final concentrations of 0.1, 0.01, and 0.001 per cent 4-chlorophenoxy acetate, 2-4- dichlotophenoxy acetate, and β-naphthoxy acetate.

These tests were made on *E. coli*, *B. subtilis*, *A. aerogenes*, *S. aureus*, and *S. marcescens*.

Tests for development of resistance.—Nutrient broths were prepared containing concentrations of 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, and 0.09 per cent of each of the chemicals. After inoculation and incubation, the tube with the highest concentration of chemical allowing growth was selected. Transfers were made from this tube to basal nutrient broth and to broth containing the next higher concentration of the chemical. Also, after incubation of the nutrient broth culture the next higher per cent solution was inoculated from it. The procedure was continued until no growth was obtained upon repeated transfer to media containing the higher concentration of the growth regulator. This was considered the limit of the resistance acquired by the test organism.

Morphologic studies.—Gram and methylene blue stains were prepared of all bacteria from both agar plates and broth cultures. Smears were made from the broth cultures at the time of each turbidity reading in an attempt to determine if any changes in morphology occurred during the incubation period.

The molds and actinomycetes were examined only for their gross morphologic characteristics.

RESULTS

Effects on growth.—*A. cloacae* when streaked on plates of nutrient agar containing serial concentrations of 0.1 to 0.000001 per cent of the sodium salts of β-indole butyric acid, 2-4-dichlorophenoxy acetic acid and β-naphthoxy acetic acid respectively and incubated, gave good growth in all concentrations except 0.1 per cent. After incubation for four days, the latter concentration permitted almost normal growth. Under the same conditions, *B. subtilis* appeared to be greatly inhibited for 24 hours, but on continued incubation good growth was obtained except at 0.1 per cent concentrations where there was complete inhibition.

Growth of *S. lutea* was greatly retarded for five days and when growth was obtained the pigment of the organisms on the test media was much deeper than for those grown on basal medium. *S. aureus* was completely inhibited for five days by 0.1 per cent β-naphthoxy acetate; with other chemicals there was decided inhibition at 0.1 and 0.01 per cent. The growth of *S. aureus* and *S. lutea* is shown in Table I. *S. indica* and *S. marcescens* did not appear at all affected by 0.1 nor *E. coli* by 0.2 per cent of growth-regulators.

Growth of *C. diphtheriae* and *B. abortus* also appeared retarded for a period with growth equal to that of the control being obtained upon continued incubation. Complete inhibition for three days was obtained at 0.2 and 0.1 per cent. These results are shown in Table II.

Test plates of molds were observed over a 10-day period. *P. notatum* and *Mucor* sp. were inhibited somewhat at a concentration of 0.1 per cent. There was marked inhibition of growth and sporulation of *A. niger* at 0.1 and 0.01 per cent of the acetates.

TABLE I

THE EFFECTS OF SODIUM SALTS OF GROWTH-REGULATORS ON THE GROWTH AND PIGMENT PRODUCTION OF *S. aureus* AND *S. lutea*

MEDIUM; SALT IN PER CENT	*S. aureus*			*S. lutea*		
	1 Day	2 Days	5 Days	1 Day	2 Days	5 Days
Control	3	4	4	4	4	4
β-indole butyrate						
0 1	1	2	4	0	0	2D
0.01	1	3	4	0	2	2D
0.001	1	3	4	0	2	2D
0.0001	2	4	4	0	2	3D
0.00001	2	4	4	0	2	3D
0 000001	2	4	4	–	1	3D
2-4-dichlorophenoxy acetate						
0 1	0	0	1	0	–	–D
0.01	1	1	.	0	1	3D
0 001	2	3	4	0	1	3D
0.0001	2	3	4	0	1	4D
0.00001	2	3	4	0	1	4D
0.000001	3	3	4	0	1	4
β-naphthoxy acetate						
0.1	0	0	0	0	1	3
0.01	–	2	3	–	2	3
0.001	1	2	3	0	2	3D
0.0001	2	3	4	0	2+ D	3
0.00001	2	3	4	0	2+	3D
0.000001	2	4	4	1	2+	3

D = Deeper pigment than on control.
Growth: 4 = excellent; 3 = good; 2 = fair; 1 = poor; — = a few scattered colonies; 0 = no growth.

There was significant inhibition of *S. griseus* and *S. lavendulae* at concentrations of 0.1 and 0.01 per cent of the salts tested. It was observed that the pigment of *S. lavendulae* was much lighter on all media containing the salts; at a concentration of 0.1 per cent β-naphthoxy acetate and β-indole butyrate, and at 0.01 per cent 2-4-dichlorophenoxy acetate, no pigment was observed. This indicates a decrease in sporulation, since the pigment of *S. lavendulae* is due to spores. On the control plate good pigmentation was obtained.

It was decided to attempt to determine more accurately the effect on the growth of bacteria of the chemicals under test. For this purpose the turbidities of broth cultures during incubation were determined by the use of the Evelyn photoelectric colorimeter. Growths of *S. aureus*, *B. subtilis*, *C. diphtheriae*, *B. abortus* and

TABLE II

THE EFFECTS OF SODIUM SALTS OF GROWTH-REGULATORS ON *C. diphtheriae* AND *B. abortus*

MEDIUM; SALT IN PER CENT	*C. diptheriae*			*B. abortus*		
	1 Day	2 Days	3 Days	1 Day	2 Days	3 Days
Control	4	4	4	1	4	4
2-4-dichlorphenoxy acetate						
0.2	0	0	0	0	0	0
0.1	0	0	0	0	0	0
0.01	2	3-	4	1	3	3
0.001	3	3	4	1	4	4
0.0001	3	4	4	1	4	4
β-naththoxy acetate						
0.2	0	0	0	0	0	0
0.1	0	0	0	0	0	0
0.01	3	3	3	1	3	3
0.001	3	3	3	1	3	4
0.0001	3	3	3	1	4	4
4-chlorophenoxy acetate						
0.2	0	0	0	0	0	0
0.1	0	0	0	0	0	0
0.01	3	3	4	1	3	3
0.001	3	3	4	1	4	4
0.0001	3	3	4	1	4	4

Growth: 4 = excellent; 3 = good; 2 = fair; 1 = poor; — a few scattered colonies; 0 = no growth.

TABLE III

THE EFFECT OF SODIUM SALTS OF GROWTH-REGULATORS ON *B. subtilis* IN LIQUID MEDIA

MEDIUM; SALT IN PER CENT	PHOTOMETRIC DENSITY				
	18 Hours	24 Hours	42 Hours	66 Hours	90 Hours
Control	0580	0605	1249	1675	.1871
4-chlorophenoxy acetate					
0.2	.0132	0177	.0177	.0177	.0177
0.1	.0132	.0132	.0132	.0132	.0132
0.01	.0304	0315	.0505	.0757	.1427
0.001	0177	.0177	.0667	.1135	1487
0.0001	.0228	0315	0706	.1249	.1739
0.00001	.0269	0315	0915	1367	.1675
2-4-dichlorophenoxy acetate					
0.2	.0044	.0044	.0044	.0044	.0044
0.1	.0044	.0044	.0066	.0088	.0088
0.01	.0223	.0315	.0505	.1024	.1549
0.001	.0315	.0410	.1024	.1337	.1580
0.0001	.0362	.0410	.1024	.1302	.1659
0.00001	0386	.0458	.1079	.1487	.1739
β-naphthoxy acetate					
0.2	.0044	.0066	.0088	.0177	.0177
0.1	.0088	.0132	.0132	.0132	.0132
0.01	.0339	.0362	.0655	.0969	.1308
0.001	.0269	0362	.0862	.1024	.1739
0.0001	0315	.0362	.1051	.1534	.1739
0.00001	.0458	.0505	.1367	.1612	.1739

S. lutea were markedly inhibited by 0.1 and 0.2 per cents of the salts and progressively less by lower concentrations. Typical data are presented in Table III for *B. subtilis.*

The only instance of stimulation of growth by low concentrations of chemical was noted for *E. coli* by 4-chlorophenoxy acetate. These data are presented in Table IV.

In order to determine whether the increase in turbidity actually represented an increase in the numbers of viable cells in the media containing small amounts of 4-chlorophenoxy acetate, serial dilutions from representative tubes were made and plated in duplicate in nutrient agar. After 24 hours incubation, colony counts were made. Results showed a good correlation between numbers of organisms per ml. and photometric densities as is illustrated by Table V.

TABLE IV

THE EFFECT OF 4-CHLOROPHENOXY ACETATE ON GROWTH OF *E. coli*

MEDIUM; SALT IN PER CENT	PHOTOMETRIC DENSITY			
	24 Hours	48 Hours	72 Hours	96 Hours
Control	0757	2076	2182	2255
4-chlorophenoxy acetate				
0 2	0315	0580	.1249	1308
0 1	0505	0969	1580	1580
0 01	0555	1739	2182	2255
0 001	0757	2111	2441	2460
0 0001	0706	2147	2403	2480
0 00001	0731	2247	2441	2441
0 000001	0783	2218	2441	2480
0 0000001	0783	2218	2441	2499

TABLE V

CORRELATION BETWEEN PHOTOMETRIC DENSITY AND NUMBERS OF VIABLE CELLS OF *E. coli*

MEDIUM	NO. ORGANISMS PER ML.		DENSITY	
	*48 Hours	96 Hours	48 Hours	96 Hours
Control	200 M.**	370 M	2076	2255
4-chlorophenoxy acetate 0.0001%	300 M.	840 M	2147	2480
4-chlorophenoxy acetate 0 0000001%	500 M.	890 M.	2218	2499

* Incubation time of tube culture when sample was plated.
** M=million.

In general, turbidity determinations indicate that there is a period during which these chemicals in low concentrations inhibit growth, but that after prolonged incubation, growth equal to or nearing that in the control media is obtained. The results described above on the effect of 4-chlorophenoxy acetate on growth of *E. coli* are the exception. This was the only case in which a significant stimulation of growth was obtained.

Biochemical reactions.—The biochemical reactions of the microorganisms tested did not appear to be affected by growth in the presence of the test chemicals. There was one exception to this; *E. coli* in 0.1 per cent 4-chlorophenoxy acetate lactose broth produced acid but no gas. On transfer from the test solution to a tube of plain lactose broth, the organism formed both acid and gas as is customary for this bacterium. Reactions in the other media tested were not changed.

Development of resistance.—Three organisms were tested for ability to acquire resistance to these chemicals; they were *B. subtilis*, *S. aureus*, and *S. lutea*.

The parent strain of *B. subtilis* grew at a maximum concentration of 0.04 per cent β-naphthoxy, 4-chlorophenoxy, and 2-4-dichlorophenoxy acetates in 24 hours. Subsequent inoculations into higher percentages gave growth in 0.06 per cent but not in 0 07 per cent except with 4-chlorophenoxy acetate. It should be noted that although *B. subtilis* did not grow in 0.07 per cent solutions, growth was obtained in plain broth inoculated from tubes of this concentration which had been inoculated with the bacterium, indicating inhibitory rather than bactericidal effect of the acetates.

S. lutea grew in media containing 0.03 per cent solutions of the chemicals. Growth was obtained in 24 hours in 0.04 per cent when transferred from 0.03 per cent solutions. After four transfers through media containing 0.04 per cent acetates, growth was obtained in 0.05 per cent solutions. No growth was obtained in concentrations of 0.06 per cent.

S. aureus grew well in a concentration of 0.05 per cent of each of the three salts in 24 hours. Transfers into higher concentrations produced no growth above 0.07 per cent until the fifth day of incubation, when in tubes of 0.08 per cent acetates, growth was observed.

Morphologic studies.—Smears from both solid and liquid media showed no change in morphology or staining reaction by Gram's method. In the stains made at each turbidity reading, there was apparently no change in cell shape or grouping at any time during the incubation period. Methylene blue stains of *C. diphtheriae* showed granules on smears from control cultures and on those of organisms grown in the presence of the growth-regulators.

No change in the gross morphology of the molds and actinomycetes was noted with the exception of the apparent decrease in sporulation of *A. niger* and *S. lavendulae*

DISCUSSION

Both streak plates and broth cultures showed that the growth of *S. aureus*, *B. subtilis*, *C. diphtheriae*, *B. abortus*, and *S. lutea* was almost completely inhibited by 0.1 per cent 4-chlorophenoxy acetate, β-naphthoxy acetate, and 2-4-dichlorophenoxy acetate. On the other hand, the gram negative bacteria, *E. coli*, *S. indica*, *S. marcescens*, and *A. cloacae* grew well in a concentration of 0.1 per cent of the salts. These findings agree with the observation that, in general, bacteriostatic agents are more inhibitory to gram positive than they are to gram negative bacteria and specifically with Culler's (1946) data for 2-4-dichlorophenoxy acetate.

In broth cultures and on streak plates, *B. subtilis*, *S. lutea*, and *S. aureus* seemed to be greatly inhibited for a period of time, but on continued incubation growth nearly equal to that of the control was obtained. Apparently, these bacteria became adapted to the chemical. Tests to determine ability to acquire resistance to the salts were performed on these three organisms, and it was found that they did adapt themselves to growth in the presence of 0.2 to 0.3 per cent increase in the amounts of the acetates.

Many investigators have reported stimulation of growth of higher plants by the chemicals used in this investigation. The only case of apparent stimulation which we observed was that produced with *E. coli* by 4-chlorophenoxy acetate in concentrations of 0.0001 per cent and lower. Here a significant increase in number of organisms was confirmed by plate counts and by turbidity determinations. Perhaps, extremely low concentrations of the other chemicals might stimulate growth of this and other organisms but no evidence was obtained to support this.

Changes in biochemical reactions were not observed except in one case. When *E. coli* was grown in lactose broth with 0.1 per cent 4-chlorophenoxy acetate added, acid but no gas was produced. Since hydrogenlyase is responsible for the production of gas from formic acid in the dissimilation of carbohydrate by *E. coli*, this enzyme may be inhibited in the presence of the growth-regulator. However, with this one exception, no evidence was obtained for the inhibition of specific enzyme activity.

It can be seen that the results obtained with 2-4-dichlorophenoxy acetate in this investigation correlate well with those found by other workers. Little has been published on the effects of the other growth-regulators on bacterial growth.

SUMMARY

Sodium salts of β-indole butyric acid, 4-chlorophenoxy acetic acid, 2-4-dichlorophenoxy acetic acid and β-naphthoxy acetic acid, when incorporated in media, were inhibitory to the growth of several gram positive bacteria in concentrations higher than 0.01 per cent. Gram negative bacteria were less readily inhibited.

Aspergillus niger and *Streptomyces lavendulae* were inhibited by 0.1 per cent of the salts and sporulation was markedly decreased by as little as 0.01 per cent.

A limited increase in resistance to the growth-regulating substances by *Bacillus subtilis*, *Staphylococcus aureus*, and *Sarcina lutea* was obtained by culturing the bacteria in increasing concentrations of the chemicals incorporated in media.

The only instance of stimulation of growth was noted for *Escherichia coli* when grown in the presence of 4-chlorophenoxy acetate in concentrations of 0.0001 per cent or lower.

No changes in morphologic characteristics or staining reactions, as a result of growth in the presence of the chemicals, were noted.

The only alteration in biochemical reaction observed was the failure of *Escherichia coli* to produce gas when grown in lactose broth containing 4-chlorophenoxy acetate.

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SOME FEATURES OF THE TRIBUTARIES TO LAKE SUPERIOR IN NORTHEASTERN MINNESOTA

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More than thirty streams, extending from Duluth to the Pigeon River, along the north shore of Lake Superior, flow from the upland into this lake. Many of these have falls and rapids in their lower courses. They either rise in glacial lakes or marshes or flow through them, having broad, boulder-strewn channels but at a comparatively short distance from the lake, their gradients are steep. Here they cut deep, narrow gorges through the basalt flows, diabase dikes and sills of Keweenawan age. The streams have taken advantage of the vertical jointing and the weaker amygdaloidal zones in excavating their channels Numerous well-developed potholes are found along the courses of some of the streams. The waterfalls and cascades are of exceptional beauty.

The rejuvenation of the streams which is responsible for the gorges, is attributed to the gradual lowering of the glacial lake levels as new outlets were opened by the recession of the Lake Superior ice-lobe, the post-glacial tilting of the land, and the deepening and widening of the Lake Superior trough by the glacier.

DESCRIPTION AND BASIC FACTS

Along the north shore of Lake Superior, the hills are close to the shoreline and cascades and waterfalls are present on many streams near their outlet. There are more than thirty rushing, tumbling streams between Duluth and the Canadian border, some of which descend as much as a thousand feet or more in their short courses to Lake Superior. The interstream divides rise to 400 feet and in some places nearly a thousand feet within a distance of a mile from the lake. There are numerous lakes at the headwaters of these streams which serve as storage reservoirs and supply a constant flow during dry seasons which adds to their value as future sources of water power.

The principal streams, named in order from Duluth to the international boundary are the Lester, Gooseberry, Beaver Bay, Baptism (Fig. 2), Manitou (Fig. 3), Cross, Temperance, Poplar, Cascade, Devil's Track, Brule and Pigeon rivers. None are large streams and their drainage areas are comparatively small. The largest is the Pigeon River (Fig. 4), which has a drainage of 628 square miles. The others, in order of size, have the following drainage areas:[2] Brule, 282 sq. mi.; Temperance, 198 sq. mi ; Poplar, 144 sq. mi.; Baptism, 135 sq. mi.; Beaver Bay, 120 sq mi.; Gooseberry, 85 sq mi.; Cascade, 84 sq. mi.; Devil's Track, 75 sq. mi.; Manitou, 71 sq mi.; Lester, 55 sq. mi., and Cross, 32 sq. mi

The streams tributary to Lake Superior on the north shore flow from the upland with gradients averaging 250 feet in a distance of about one and one-half miles. The rapids and falls begin at points as close to Lake Superior as .05 mile, up to points greater than a mile. The altitude of their courses on the glaciated upland varies from 1650 to 1950 feet, averaging 1800 feet. In general, the minor tributaries on the north shore of Lake Superior have a rapid fall from source to mouth except for short distances through lakes or swamps. When traced from their outlets at Lake Superior to their sources, the general sequence of features is as follows: at the junction of the river and the lake there is usually a gravel bar

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[1] ACKNOWLEDGMENTS: The field work was carried out by means of aid from a grant from the William Wilson Research Fund at the College of Wooster.

[2] Leverett, Frank. Moraines and Shorelines of the Lake Superior Basin. U. S. Geol. Survey, Professional Paper 154, p. 11.

thrown across the mouth by the vigorous waves from the lake. Because of the absence of a bar at its mouth, the Temperance River was given its unique name. Behind the bars there may be a gentle gradient with rather quiet water for a short distance. In some instances, the falls and rapids begin not far back from the shoreline. For a distance of a mile, more or less, the streams flow through narrow gorges, leaping from ledge to ledge by cascades and waterfalls. Beyond the falls and rapids on the upland, the streams open into wide, flat-bottomed, boulder-strewn channels. Their courses on the upland do not appear to follow any definite preglacial channels and wind about through lakes and swamps, following the lines of least resistance. This condition is characteristic of immature drainage in glaciated regions.

The small tributaries to Lake Superior on the north shore, in Minnesota, are associated with some of the finest scenery in the north country. They pass through coniferous forests in deep, narrow, angular, vertically-walled gorges through which the water leaps from pothole to pothole by a series of falls or rapids. They are, in many instances, easily accessible from the highway by trails constructed by the State Highway Department.

Perhaps the most spectacular of the falls are those on the Pigeon, Manitou (Fig. 3), Temperance, Cascade, Devil's Track (Fig. 6), Brule, Gooseberry and Cross rivers. The Pigeon River has the highest falls (Fig. 4), 120 feet, and a narrow spectacular gorge in its lower course. The Temperance River is unique for its extremely narrow gorge which is less than ten feet wide in places and 50 to 75 feet deep. The thunder of the water as it passes from ledge to ledge, through openings not more than three feet wide, is awe-inspiring.

One of the most interesting features in the gorges of some of these streams is the well-developed potholes. In the courses of the Temperance and Cascade rivers these potholes are especially well displayed (Fig. 5). In the opinion of the writer, there are few places in the country where one can see a finer display of potholes. Cut out of the solid rock, their sides are smoothly polished. The gorges of the Temperance and Cascade rivers, for long distances, consist of a series of potholes, some large and others small. These streams flow through a forested region and their waters carry little material in suspension The sediment is made up of gravel, cobblestones and boulders, mainly of glacial origin, which makes excellent material for grinding potholes in solid rock. In a number of instances, the writer found potholes from 6 inches to a foot or more in diameter, cut down vertically in the diabase for depths of two to three feet. So perfect are they that they appear to have been cut by a drill. The pebbles which served as grinding tools are still present in some of them. In some cases, the potholes are huge, being as much as 25 feet in diameter and shaped like a jug. The junction between potholes is frequently sharp and triangular in outline. At one spot in the falls of the Brule (Arrowhead) River, a large part of the water dashes down into a pothole or circular pit about 8 to 10 feet in diameter, known as the "Devil's Kettle." The water disappears from view and the place where it makes its reappearance at the surface is not visible. Hence, the belief that the pit is bottomless and has no outlet. The water probably finds an outlet to the main channel by a subterranean course, not visible at the surface. Above the gorge of the Temperance River there is evidence that the water flowed originally in a broader channel. A deep abandoned pothole occurs along the trail not far from the edge of the gorge, indicating that the stream at higher levels abandoned its course in places and sought new less resistant avenues of escape as it cut downward.

The conditions for the formation of the narrow angular gorges and potholes are ideal. The Keweenawan flows have amygdaloidal zones which are weaker and less resistant sedimentaries occur interstratified with the flows. The diabase

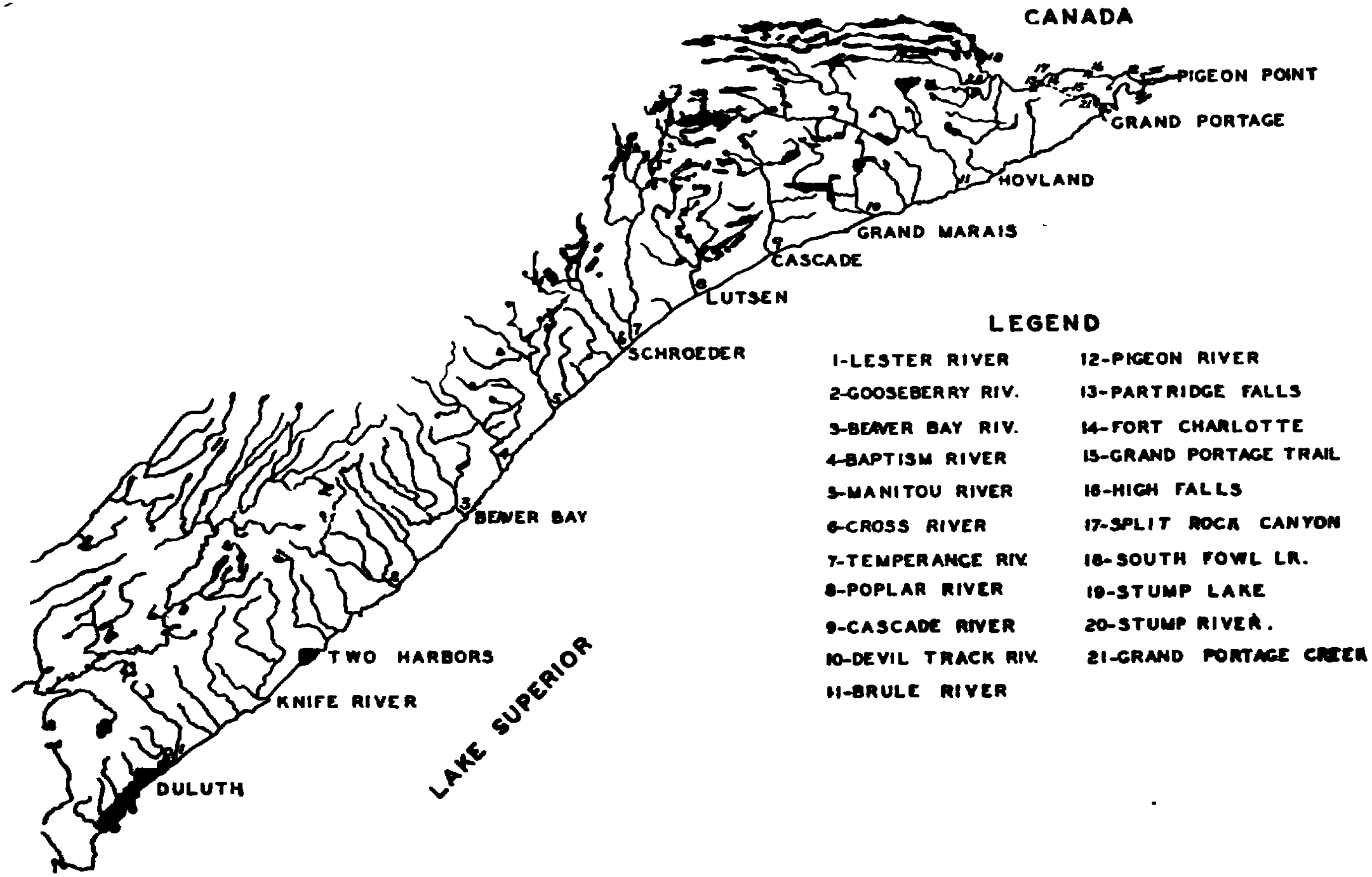

FIG. 1. A map showing some features of the tributaries to Lake Superior in northeastern Minnesota.

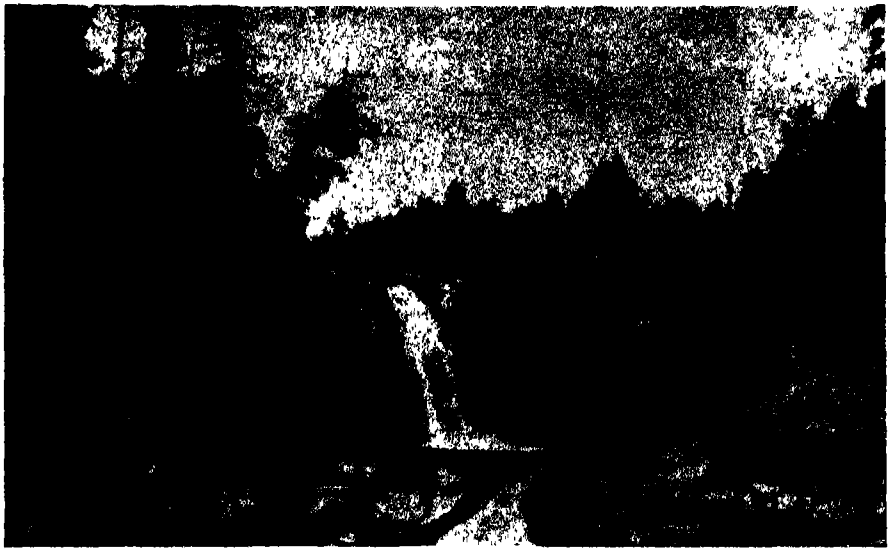

FIG. 2. Falls of the Baptism River.

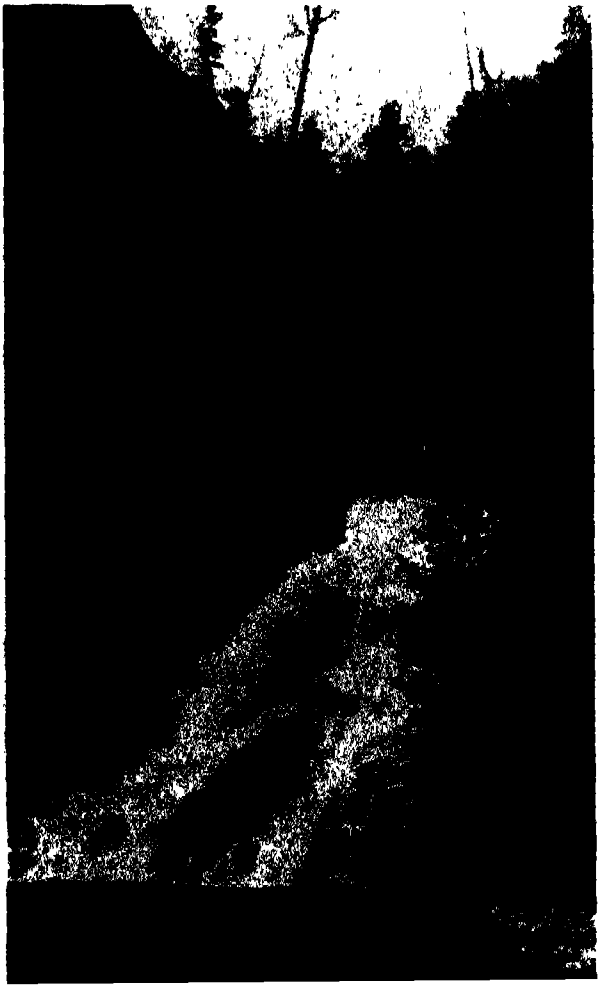

FIG. 3. Manitou Falls on Manitou River.

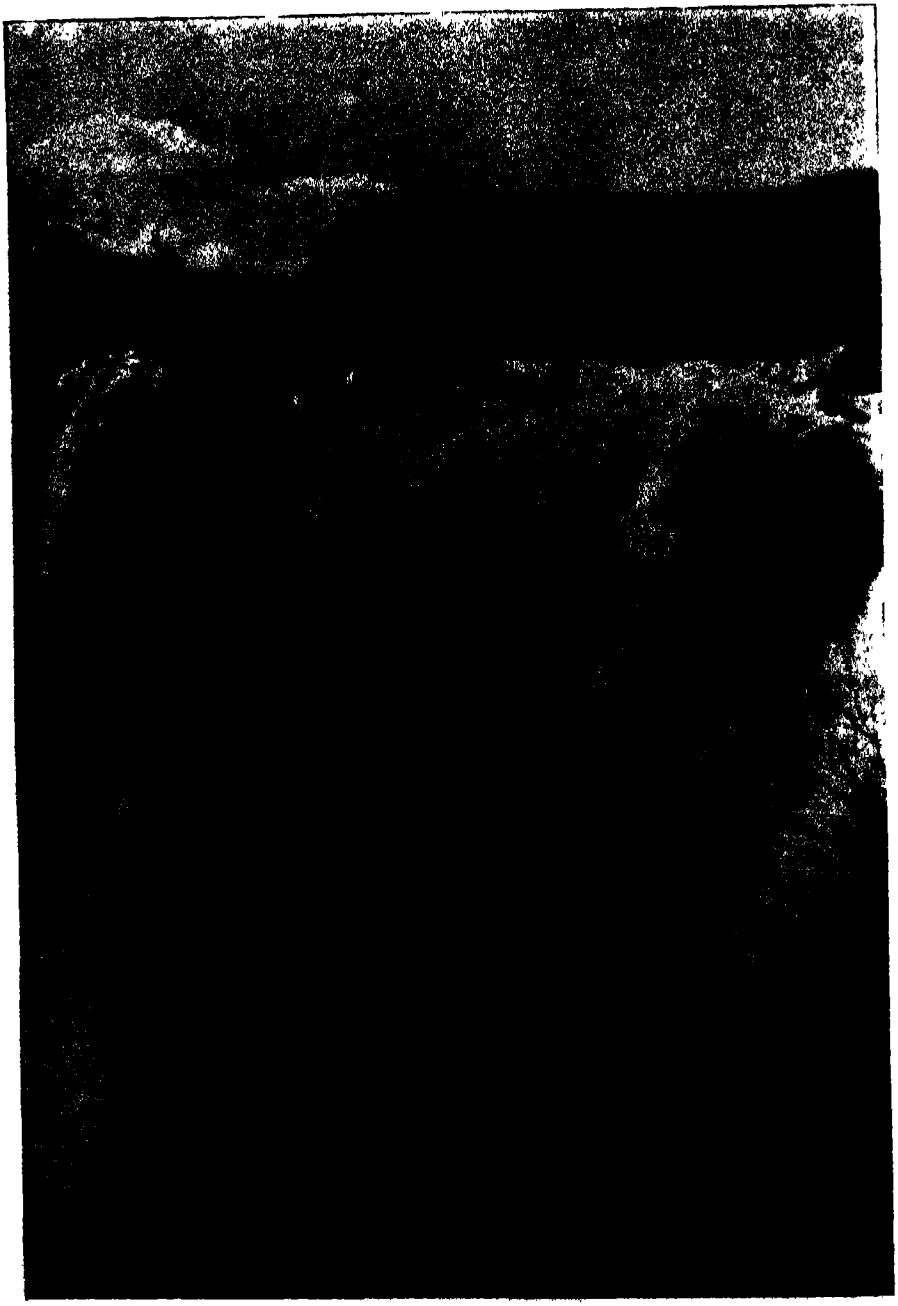

FIG. 4. High Fall on Pigeon River.

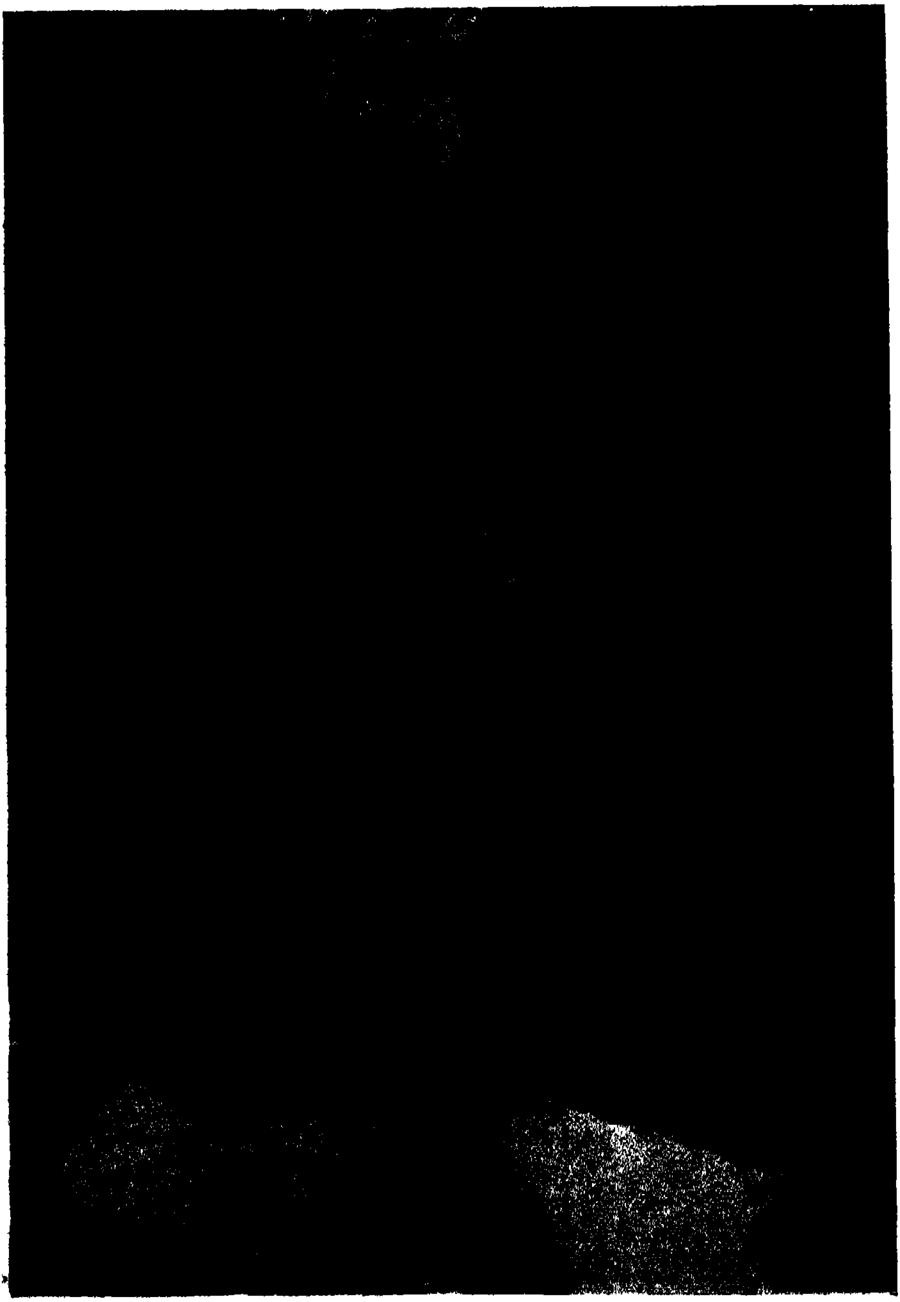

FIG. 5. Cascade Falls on Cascade River.

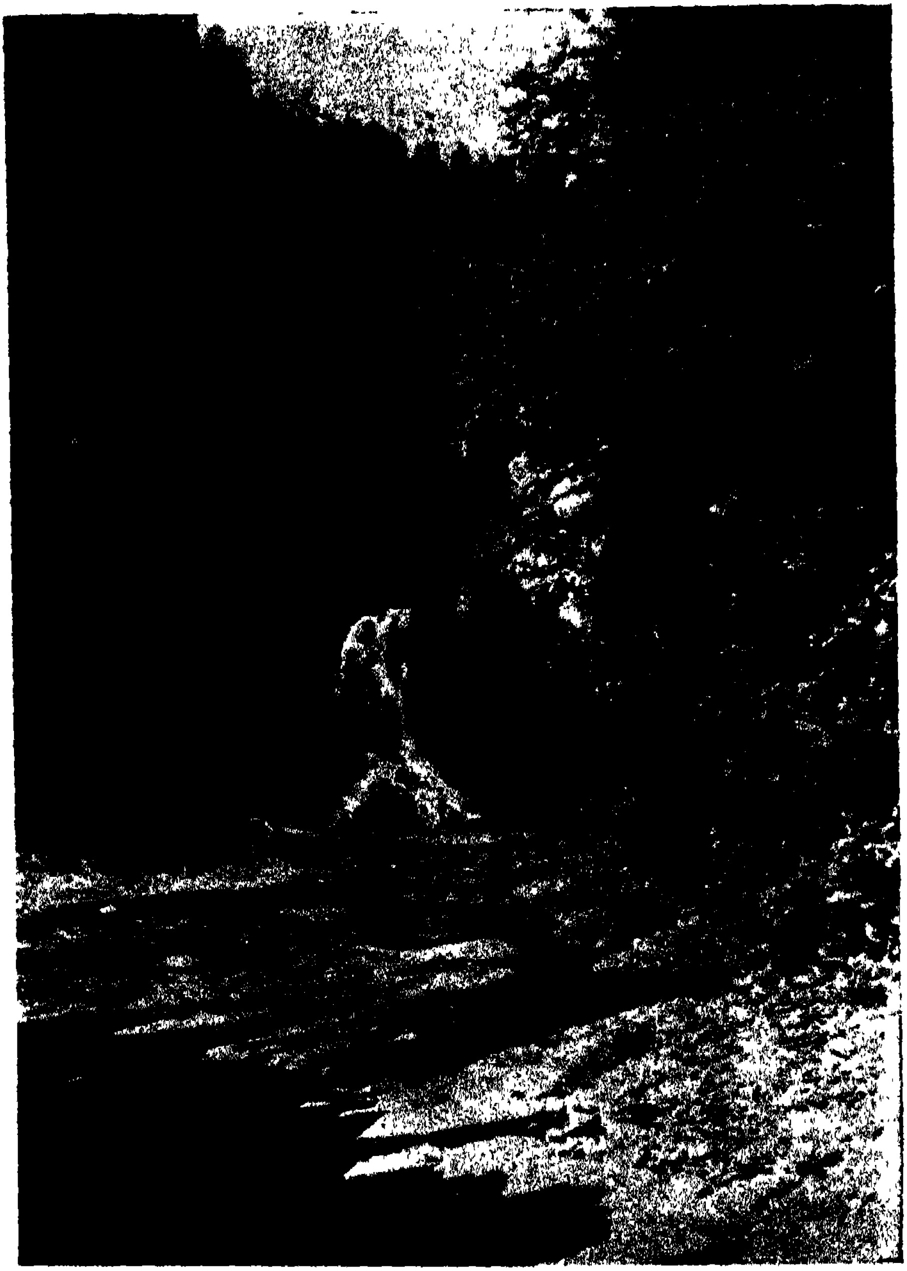

FIG. 6. Devil Track Fall on Devil Track River.

dikes and sills have well developed vertical jointing along which the streams have cut their channels.

EFFECTS OF GLACIATION

In preglacial time the drainage lines were oriented in a general northeast-southwest direction, the result of the monoclinal ridge and valley topography of the area. No doubt, the drainage in northeastern Minnesota was quite different from that of today. It is probable that the body of water now known as Lake Superior did not exist in preglacial time. It is more likely that its present site was a broad lowland occupied by a river system. Before the ice-age, the streams in the area occupied broad open valleys of low gradient, such as characterize a region in an advanced stage in the cycle of erosion. The advent of the ice-sheets changed that condition; old streams were obliterated; others were forced to take new courses and entirely new streams came into being. Numerous lakes and swamps are now present where none existed before.

Many of the youthful post-glacial streams have cut deep, narrow gorges having numerous waterfalls and rapids. One cannot but be impressed by the size and depth of some of these post-glacial gorges. It may be that the enormous volume of melt-water from the shrinking ice-sheets was responsible for the rapid erosion necessary to produce gorges of such width and depth.

The Pigeon River has a comparatively low gradient in its lower course, as compared with the slopes of the smaller streams along the north shore of Lake Superior. This is accounted for by the fact that the Pigeon River is located principally on the Rove Slate which is weaker than the Keweenawan flows and intrusives. Pigeon River has an average gradient of 28 feet per mile in a distance of 30 miles. For a distance of one and one-half miles from its mouth, it has eroded its channel down to the level of Lake Superior, whereas the other streams tributary to the lake descend over rock ledges to points within short distances of the shoreline.

From a point above Partridge Falls about 20 miles from its outlet to one about 1.7 miles from its mouth, the Pigeon River descends through deep, narrow gorges by a series of waterfalls and rapids. From South Fowl Lake to Partridge Falls, a distance of 10.6 miles, the gradient of Pigeon River is only 11.3 feet per mile. Along the lower 20 miles the gradient averages 33 feet per mile. The gorge, cascades and falls are conspicuous where the river cuts through the resistant diabase sills and dikes. At High Falls (Fig. 4), the Rove Slate is intruded by a dike, trending N. 50 E., which forms the falls and a ridge on each side of the river. The fall of large masses of diabase from the face, resulting from prominent jointing, produces a vertical wall over which the water plunges a distance of 120 feet. The presence of a second dike, a short distance below High Falls is responsible for another cataract of lesser height. Partridge Falls, 50 feet high, was formed by the intrusion of a diabase dike into the Rove Slate.

On Pigeon River, about one and one-half miles northeast of Partridge Falls, is Split Rock Canyon, a deep narrow gorge cut for the most part in the Rove Slate. The river has cut its channel so rapidly since the recession of the ice-sheet, that little time has elapsed for widening the gorge by weathering and slope wash.

For a distance of about eight miles above Partridge Falls, the Pigeon River flows parallel to the diabase ridges and the escarpment formed by the Keweenawan flows, through a broad open valley on the Rove Slate, with continuous swamps to a point near the outlet of South Fowl Lake and up the Stump River lowland to Stump Lake. There is a great contrast in the course of the Pigeon River, below and above Partridge Falls; the marked difference of a broad, open swampy valley above the steep-sided, narrow gorges with cascades and waterfalls below that point. Apparently the post-glacial Pigeon River has not entrenched its gorge in the old preglacial valley above Partridge Falls.

The unusual course of the Pigeon River is the result of glaciation. As the ice-sheet receded, ponded waters were forced to the south of the ice front which found outlets through the lowest places, including the gaps in and between the diabase ridges where the present cascades and waterfalls are located. It is possible that the glacial waters followed the courses of minor streams which in preglacial time cut across the ridges through gaps or low places.

The preglacial Pigeon River may have drained through one of the broad valleys farther south, perhaps through the swampy lowland now occupied by Stump River and its continuation in a southeasterly direction. Or its route may have been through the old valley above Partridge Falls, following the lowland eastward from the site of Fort Charlotte and along the route through the gaps now followed by the Grand Portage trail which parallels the course of Grand Portage Creek to Lake Superior.

There is evidence to suggest that a preglacial stream existed on the site of the lower Pigeon River. Its mature valley in preglacial time passed through gaps in the diabase ridges similar to those northwest of Grand Portage. The preglacial streams that occupied the present sites of the lower Pigeon River and Grand Portage Creek, flowed through broad valleys where Pigeon Bay and Grand Portage Bay are now located. These rivers, doubtless, emptied into a larger stream which occupied the broad lowland now covered by Lake Superior.

Several factors combine to account for the falls on the north shore tributaries to Lake Superior. The first has to do with the gradual lowering of the lake level since the withdrawal of the ice-sheet from the Lake Superior basin. According to Leverett,[3] the elevations near Grand Marais indicate the highest beaches at 1,206 to 1,275 feet above sea-level or 604 to 623 feet above the present level of Lake Superior. The Algonquin beaches are present at Grand Marais at 1,042 feet above sea-level. Several lower levels are indicated at 785, 760, 725 and 630 feet above sea-level in the same locality.[4] North of Hovland, the upper limit of lake action is about 1,300 feet. At Pigeon River, the upper limit is slightly above that at Hovland and at Mt. McKay at Fort William, Ontario, the highest beach level is 1,350 feet above sea-level or 748 feet above the level of Lake Superior.

According to Leverett[2], the highest beaches at Duluth appear at about 1,135 feet and the lowest at not more than 1,085 feet The lake levels at Duluth are 60 feet higher than on the south side of the lake, in a distance of 24 miles. It appears that there has been differential uplift of two and one-half feet per mile since the recession of the ice. Leverett points out that the differential uplift of the highest beach, from a point near Schroeder to Poplar River is 33 feet in 13.3 miles or 30 inches to the mile, along the course of the beach. The rate is nearly as great from Lutsen to Grand Marais or to the hill northwest of Hovland where the highest beach is 1,300 feet above sea-level.

The high level of Lake Duluth would bring the water up on the upland to the north. As the level dropped, the gradient to the north shore tributaries was increased. Each successive drop in lake level, produced a sharp rejuvenation at their mouths. Furthermore, the gradual differential uplift and tilting of Lake Superior and its predecessors has produced results favorable to the constant rejuvenation of the streams flowing into Lake Superior from the north. One should not underestimate the importance of the tremendous erosion accomplished by the ice lobe which occupied the Lake Superior lowland and its effect in the steepening of the adjacent slopes. Glacial erosion may have produced hanging valleys along the north shore.

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[3] Idem. 1, p. 59.

[4] Grout, F. F., and Schwartz, G. M. Rove Formation, Minnesota Geological Survey, Bulletin 24, p. 10.

The steep shores of Lake Superior have been attributed to faulting. In the writer's opinion, not enough emphasis has been placed on the effects of glacial erosion in the Lake Superior trough. The lake basin was deepened and its sides eroded, producing on the north side, a steep regular slope which has been modified by the waves and currents since the ice-age.

A feature which can be pointed out here, is that the convex profile of the north shore tributaries to Lake Superior is significant.[4] This is interpreted by the writer as an indication that the erosive power of the streams has not been able to keep pace with the rise of the land.

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[4] Idem. 1, Profile of the St. Louis River, Figure 3, p. 9.

REMOVAL OF SODIUM FROM BIOLOGIC MENSTRUUMS BY CALCIUM ZEOLITES

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AND
ROBERT D. BARNARD[1]

The exchange resin nature of the natural and artificial zeolites has found wide application in industrial water-softening and ammonia removal processes. More recently polysterene resins have been used biologically in the removal of excess hydrogen ion from gastric juice and to inhibit clotting of blood specimens by the removal of calcium ion. In a search for a cheaper material with which to decalcify and recalcify blood plasma reversibly, experiments were undertaken with the commercial zeolite, permutit. During the course of coagulation of citrated blood plasma with calcium zeolite it was observed that a stoichiochemical equivalent of sodium was removed from the plasma and that the zeolite was completely inert insofar as any apparent denaturation effects were concerned. Since the removal of sodium ion may be a desirable end in the treatment of congestive heart disease and thrombophlebetic edema and since this might be accomplished from those menstruums where the presence of calcium zeolites would not be prohibitive (intestinal contents) the feasibility of sodium removal by this means from such menstruums was explored.

Preliminary experiments indicate that the sodium content of neutralized peptic digests can be reduced to traces by one hour's contact with specially prepared calcium permutit. For effective sodium removal within this interval of time, the volume of the permutit must be from one-third to one-half that of the elutate. The administration of permutit in the treatment of congestive heart failure would therefore have to be supplementary to an initially salt-poor diet.

No deleterious effects have so far been observed from the administration of calcium zeolite to human subjects in doses of 10 grams, three times daily.

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[1] The experimental work upon which this preliminary report is based was conducted on the Medical and Laboratory Services of the Veterans Administration Hospital, Batavia, N. Y.

LYGAEIDAE COLLECTED IN WESTERN TEXAS, WITH A NEW LYGAEOSPILUS FROM CALIFORNIA

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For a number of years Prof. and Mrs. J. N. Knull, the former Curator of Insects, Department of Zoology and Entomology at The Ohio State University, have collected insects in western Texas and elsewhere in the southwestern states. In this list of Lygaeidae all records are from western Texas with exception of new species of *Lygaeospilus* from southern California.

Subfamily **Lygaeinae**

Oncopeltus fasciatus (Dallas), Gillespie Co., V-6-46; Chisos Mts., VII-9-'36, VII-17-'46; Davis Mts., VIII-22-'36; VIII-2-'37; Brownsville, V-31-'39.
Oncopeltus sexmaculatus Stål, Brownsville, VIII-8-'37.
Lygaeus reclivatus Say, Chisos Mts., VII-17-'46.
“ “ *enotus* Say, Chisos Mts., VII-17-46.
“ *kalmii* Stål, Davis Mts., V-27-'35; Uvalde, V-23-'35.
“ *belfragei* Stål, Gillespie Co., VI-14-'34; Davis Mts., VII-2-'40.
“ *uhleri* Stål, Davis Mts., VIII-22-'36.
“ *lineola* Dallas, Brownsville, V-15-'35, VIII-8-'37.
“ *carnosulus* Van Duzee, Brownsville, V-8-'35, VIII-8-'37.
“ *nigrinervis* Stål, Val Verde Co., V-13-'46.
“ *bicrucis* Say, Chisos Mts., VIII-9-'36; Davis Mts., VI-8-'39; Maud, IV-29-'41.
“ *lateralis* Dallas, Davis Mts., V-27-'35, VII-6-'36; Lasca V-30.
Lygaeospilus tripunctatus (Dallas), Gillespie Co., IV-7-'46; Uvalde, V-30-'36.
“ *pusio* (Stål), Gillespie Co., V-7-'46.
Lygaeospilus fusconervosus new species.

General color fuscous, with the following parts fusco-rufous: anterior margin, humeral angles and posterior median line of pronotum, corium with costal margins anteriorly, inner claval and commissural margins, a small spot on posterior margin at apex of median (cubitus) vein. Surface between the fuscous veins dull pruinose. Membrane opaque, dull slate gray, outer and basal margins in part narrowly margined with white, veins fuscous.

Vestiture of head, pronotum and corium consists of very fine, short, inclined hairs, those of corium somewhat longer; devoid of the long, soft pile characteristic of the other two species in the genus.

Beneath, with following parts sordid white: bucculae, wide anterior margin of prosternum, posterior margins of pro- and mesopleura, and acetabular caps; orifices black; lateral margins of venter obscurely rufo-fuscous. Femora fuliginous.

Head just over one-fourth wider than long, unicolorous. Ocelli rubinous. Antenna almost half as long as entire body, second segment over twice as long as basal, third segment about one-third longer than basal and nearly one-third shorter than second, terminal a little shorter than second and covered with very fine, short, inclined hairs. Pronotum about one-third wider than long, sparsely, coarsely punctate on depressed surfaces before and behind cicatrices; transverse area bearing cicatrices somewhat elevated, followed by a median, longitudinal carina extending to posterior margin. Scutellum nearly one-third wider than long, deeply depressed at base and posteriorly on either side of middle, appearing as rounded pits, between which is a rounded carina extending to apex. Corium with veins (Cu and R+M) strongly elevated. Membrane scarcely extending beyond apex of abdomen. Length ♂ 4.7 mm.

Type male: Santa Rosa Mts., California, VI-25-'46 in collection of The Ohio State University. Described from a single specimen.

In his revision of the genus *Lygaeus* (Proc. Ent. Soc. Washington, XXIII, 1921) the author briefly described the new subgenus *Lygaeospilus* with *Aphanus tripunctatus* Dallas as type and added *Lygaeus* (*Melanocoryphus*) *pusio* Stål to it. In a more recent study of the genus he has come to the conclusion that this as well as several other subgenera of Stål should be raised to generic rank.

Lygaeospilus is most closely related to the European genus *Lygaeosoma* Spinola. It can be distinguished from that genus by the longer commissure, by the erect or inclined hairs, at least on the corium, as well as by the black orifices.

Nysius californicus alabamensis Baker, Chisos Mts., VII-17-'46; Davis Mts., VI-2-'37.
" *tenellus* Barber, Davis Mts., VI-2-'37.
" *raphanus* Howard, Davis Mts., VIII-2-'37.

Subfamily **Blissinae**

Ischnodemus macer Van Duzee, Davis Mts., VII-2-'40, VII-28-'46; Chisos Mts., VII-17-'46.

Subfamily **Geocorinae**

Geocoris punctipes (Say), Davis Mts., VII-6-'32; Uvalde, VI-30-'36.
" *lividipennis* Stål, Gillespie Co., V-2-'35, VI-14-'34.

Subfamily **Pachygronthinae**

Phlegyas annulicrus Stål, Gillespie Co., V-7-'46.

Subfamily **Rhyparochrominae**

Heraeus plebejus Stål, Brownsville, V-8-'35, V-22-'35.
" *cinnamomeus* new species.

Head, pronotum and scutellum cinnamomeus; corium testaceus, ferrugineusly punctate, tinged with castaneous on apical angle, preceded by an obscure paler, transverse, testaceous area extending to costal margin. Antenna testaceous, apices of basal three and all of terminal segment, brownish. Legs pale yellow testaceous with apices of all femora faintly brown. Membrane tinged with brown, inconspicuous spots at base and apex.

Head shining, narrowly oval, about one-third longer than wide (60x38); preocular very nearly one-fifth longer than posterior part; viewed laterally eye rather large, occupying about half depth of head; vertex very little elevated above dorsal line of eye. Antenna about three times as long as head; second segment about twice as long as basal; third segment a third longer than basal and terminal seomwhat shorter than second. Pronotum less shining, as long as head; anterior lobe much longer and narrower than posterior and very nearly smooth; posterior lobe a little paler, coarsely punctate. Scutellum dull, a little longer than wide, coarsely punctate on depressed base and along sides. Beneath cinnamomeous, pleura darker and duller than abdomen; posterior margin of metapleura and acetabular caps a little paler. Fore femur rather strongly incrassate, with a premedian larger spine, between which, the apex with two rows of spinules. Length 6.5-7 mm.

H. cinnamomeus is very closely related to *H. coquillettei* Barber. In fact this new species was included by me in the series of specimens of that species when the description was drawn up. The cotypes of *coquillettei* from Brownsville, Texas, should be referred to *cinnamomeus*, which is distinguished chiefly by the duller appearance of most parts, relatively larger eyes and more abruptly rounded basal part of head.

Type male: Brownsville, Texas, VI-5-'04 (H. S. Barber collector), and 22 paratypes, males and females, from the same locality in the collection of the United States National Musuem; 7 paratypes, same locality (D. J. and J. N. Knull), collection of The Ohio State University; 5 paratypes, same locality, collection of Texas A. and M. College; 2 paratypes, same locality, author's collection.

Ligyrocoris abdominalis (Guérin), Uvalde, V-30-'36.
" *aurivillianus* (Distant), Brownsville, VI-8-'34.
" *nitidicollis* (Stål), Val Verde Co., VI-28-'40.
" *nitidulus* (Uhler), Davis Mts., VII-22-'36, VIII-22-23-'36, IX-2-'40.

Pachybrachius vincta (Say), Brownsville, V–15–'35.
Paromius longulus (Dallas), Brownsville, V–15–'35; Gillespie Co., VI–23–'40.
Zeridoneus knulli new species.

The following parts somewhat shining black: head, pronotum, scutellum, except at extreme apex, which is testaceous yellow; corium dull black, except for narrow yellow testaceous costal margin. Antenna testaceous, apical part of third and all of fourth segment, fuscous. Legs yellow testaceous; broad middle region of anterior femora and apices of tibiae fuscous. Beneath black.

Very similar to *Z. costalis* (Van Duzee) in general appearance and relative proportion of body parts. Anterior lobe of pronotum is shorter in relation to posterior lobe than in *costalis* and more sparsely and less coarsely punctate; constriction between the two lobes is deeper, as viewed both dorsally and laterally, and spines of the fore femora are arranged differently in *knulli*. The two post median longer spines are set closer together with no intermediate smaller spines, and preapical spines more numerous.

Type male: Gillespie Co., V–7–'46. In collection of The Ohio State University.

Extochiomera albomaculatus (Distant) Biol. Centr. Amer., Rhynch. I, 400, 1893, Plt. XXXV, Fig. 6.

Both Mr. Van Duzee and the author misidentified this species as Guérin's *minima* from Cuba. Recent receipt of a specimen of the true *minima* from that island indicates quite clearly that we were mistaken. It therefore becomes necessary to find another name for this rather common species occurring in Mexico, Central America and southern United States. Although Distant's description of *albomaculatus* is very inadequate, his figure leaves little doubt that his name will have to be adopted. Brownsville, V–8–'35.

Ozophora depicturata Barb., Uvalde Co., V–3–'41.

Science and the Planned State

"Science" is defined as the "organized body of general demonstrable knowledge about the matter of the universe" without regard to its relationship to human welfare. Science becomes technology when these human relationships become its primary concern. The overlapping of science and technology is admitted, but the distinction is held still valid.

The "planned state" is totalitarianism. Under totalitarianism, the work of the scientist becomes mere technology as all research must then necessarily bear an obvious relationship to the needs of mankind. In modern totalitarian governments, it must even bear a supportive relationship to the currently controlling political philosophy.

Mr. Baker's concern is that Soviet science is currently being so highly (and undeservedly) touted. He brings to attention another side of the story:

(1) The absence of a single Soviet contribution from a list of the 27 "most important scientific discoveries made between the two great wars."

(2) The awfully warped attitude of the politically powerful Soviet geneticist, Lysenko.

(3) The production of an "unduly high proportion of bad and suspect science" by Soviet scientists.

He also endeavors to demonstrate that science will deteriorate under any form of planning. There is, he admits, a place for planning and teamwork in science. This place is in the follow-up of a new line of investigation *after* the primary original discovery has been made. "Science can progress rapidly only if scientists are free to expand the bounds of knowledge wherever, at any given moment, they are expansible." The discovery of the vulnerable points *cannot* be planned because there is too great an element of chance involved. Science by nature cannot prosper under totalitarianism because by nature the scientist accepts the authority of no one and needs the liberty to practice this attitude.—*Elton F. Paddock.*

Science and the Planned State, by John R. Baker. 119 pp. New York, The Macmillan Co., 1945. $1.75.

HOLOCONOPS IN THE WESTERN LAKE ERIE REGION (DIPTERA: HELEIDAE)[1]

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In his generic synopsis of Heleidae, Johannsen (1943) listed two Nearctic species in the Leptoconops group, which includes Holoconops. Both of these are from the western and southwestern states.

Leptoconops torrens Townsend was described from New Mexico as belonging to the genus Tersesthes. The first specimens were taken at an elevation of 7000 feet while biting horses, particularly around the eyes (Townsend, 1893). Hoffman (1926) reported and described *L. carteri* from the Sacramento Valley in California. There in late spring and early summer the gnats are vigorous biters, attacking exposed skin or crawling under clothing, and often causing severe itching and swelling. They are reported as being so abundant at times that work in the fields is almost unbearable. Freeborn and Zimmerman (1934) described the male of *L. torrens* and presented evidence indicating that *carteri* is a synonym of *torrens*. They incidentally mention specimens from Texas, thereby extending the known range of the species. Johannsen (1943) also mentions the occurrence of *torrens* in Colorado.

Holoconops kerteszi Kieffer was described in 1908 from Egypt. The species was subsequently reported from the mountainous region of Tunis and later from lower altitudes. In his revision of the genus Leptoconops, Carter (1921) added a variety, *americanus*, on the basis of specimens from Utah but freely admitted the absence of good distinguishing characters. Later (1934), Freeborn and Zimmerman studied California specimens which seemed to unite *americanus* with the typical *kerteszi*. In California, the species inhabits a district of wind-swept hills, salt marsh, dune, and beach (Freeborn and Zimmerman, 1934). The specimens first collected in Utah were recorded as "biting devilishly" (Carter, 1921).

On a collecting trip in 1942 along the sandy beach of Lake Erie northwest of Lakeside, Ohio, between East Harbor and West Harbor, the writer's attention was suddenly drawn to a minute punky viciously biting his lower arm. Because of its minute size, the specimen was collected separately in a one-dram vial containing grain alcohol. At the time it was thought to be a specimen of Culicoides. On examination in the laboratory, however, it was found to belong to the Leptoconops group of punkies. The closest described relative was obviously *Holoconops kertessi*. At first it was thought to be a variant of that species but closer examination revealed differences which seemed too great to be overlooked. It was hoped that additional specimens could be located during widely spaced trips to the area but inasmuch as five years have elapsed without success the specimen is being described as representing a new species.

Holoconops catawbae new species

Female.—Head, thorax, and abdomen nearly uniform reddish brown. Thorax unstriped. Antennae, legs, and lamellae somewhat lighter; legs tending to be lightest in metatarsal area. Frons minutely hairy (430×), with a few larger hairs at the level of the upper margin of the eyes. Eyes reniform, naked. Antennal flagellum (Fig. 2) with 11 joints; terminal joint about 2.5 times longer than wide; basal joint pyriform, all others more or less globular. Terminal antennal segment very slightly longer than three preceding segments. Palps (Fig. 1) probably with four joints but basal joint very indistinct; palps therefore appearing to be three-jointed. Ante-

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[1] Contribution from the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio.

penultimate palpal joint small, subspherical; penultimate joint elongate pyriform, with conspicuous sensory pit distinctly distad of middle; terminal joint stalked, clavate. All palpal joints with irregular, transverse rows of setulae (430×). Thorax with scattered hairs about as long as those of antennal flagellum. Scutellum with four distinct bristles. Wings (Fig. 5) whitish, the surface covered with microtrichia (100×); macrotrichia absent. Costa undeveloped except perhaps between apices of R_1 and R_5. Subcostal-radial fusion fairly complete, a longitudinal vein, probably R_1, dividing the area lengthwise. R_5 (designated a longitudinal fold by some authors) distinct to near wing apex, Anterior branch of media present but indistinct, posterior branch absent. Both branches of cubitus visible but evanescent apically. Halteres pale. Metatarsi moderately spiny; other tarsal joints with a few spines. Tarsal claws equal, simple, and without a basal tooth. Fourth tarsal joint on all legs shorter than fifth. Hind tarsus with proportions as follows: 13–10–5–3–4. Abdomen with minute hairs (215×); longer hairs confined to venter and to terminal segments dorsally. Lamellae (Fig. 3) elongate, hairy. Spermathecae (Fig. 4) lemon-shaped, rounded dorsally but showing short stalks ventrally. A small spermatheca-like body visible just posterior to second spermatheca. Wing length, 0.82 mm. Length of lamellae, 0.14 mm. Total length, including lamellae, 1.2 mm. (as measured before specimen was mounted on a slide).

Holotype female, Lakeside, Ohio, July 8, 1942, M. W. Boesel. Preserved in 95 per cent grain alcohol until 1944; then mounted on a glass slide in balsam. Type in author's collection.

KEY TO NEARCTIC SPECIES OF THE LEPTOCONOPS GROUP

1. Antennal flagellum with 13 joints; males .... (2)

1. Antennal flagellum with 11 or 12 joints; females .... (3)

2. Ninth tergite with two short fleshy lobes ventrad of termination, each bearing two long stout bristles; scutetlum with six bristles.................... **Leptoconops torrens** ♂

2. Ninth tergite with two long finger-like terminal projections, each with a very short inconspicuous bristle near its middle; scutellum with four bristles..... **Holoconops kerteszi** ♂

3. Antennal flagellum with 12 joints; scutellum with six bristles; abdomen brown, distinctly paler than thorax; total length 2.2 mm.; wing length 1.1 mm..... **Leptoconops torrens** ♀

3. Antennal flagellum with 11 joints; scutellum with four bristles........................ (4)

4. Penultimate palpal joint with pore near middle; ultimate palpal joint slightly swollen distally; antepenultimate palpal joint elongate, cylindrical, hardly or little wider than succeeding joint; head and thorax black, abdomen dark brown; legs dark brown; veins R_5 and M_{1+2} convergent apically; total length 1.5–2.1 mm.; wing length 1.1–1.3 mm. **Holoconops kerteszi** ♀

4. Penultimate palpal joint with pore distinctly distad of middle; ultimate palpal joint stalked, apical two-thirds definitely broadened; antepenultimate palpal joint subspherical, distinctly broader than base of succeeding joint; entire body uncoilorous reddish brown; legs light brown; veins R_5 and M_{1+2} subparallel or slightly divergent apically; total length 1.2 mm.; wing length 0.82 mm........... **Holoconops catawbae** ♀

DISCUSSION

At first it was considered probable that the specimen collected in Ohio had been carried into the region from the western or southwestern states. There are familiar accounts of small insects being carried great distances in the air. Specifically, Freeborn and Zimmerman (1934) speak of 'black alkali' locations in California which act as foci from which these "black gnats" are blown by winds over large areas. It is interesting but perhaps not too significant to note that a southwest wind with a velocity of 36 miles per hour was recorded for Cleveland

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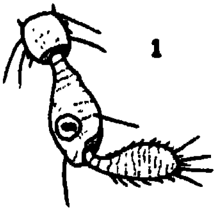
EXPLANATION OF PLATE

FIGS. 1–5. Details of *Holoconops catawbae* n. sp., female.

Fig. 1. Palp. Fig. 2. Antenna. Fig. 3. Lamella, lateral view. Fig. 4. Spermathecae, lateral view. Fig. 5. Wing.



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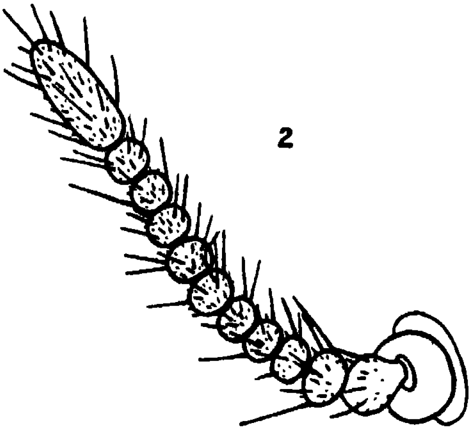

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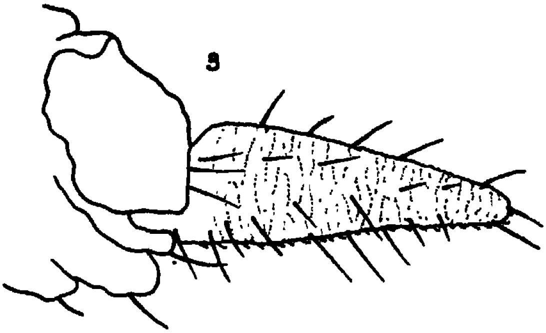

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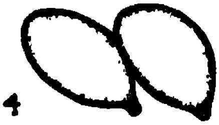

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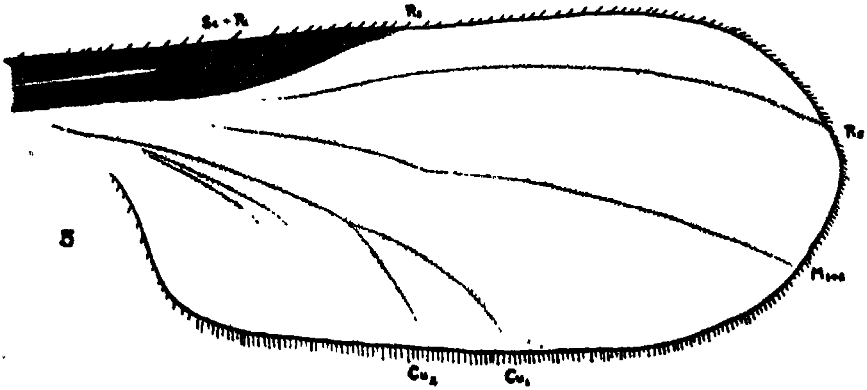

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on June 30, and a south wind of 40 miles per hour was recorded for the same city on July 3, 1942. In order to have been transported from the nearest recorded locality (Utah) to western Lake Erie, the punky would have had to travel nearly 2000 miles. When the individual was carefully studied and found to differ from *H. kerteszi* in a number of respects, the theory of transmission by air currents or other means seemed much less attractive.

An argument in favor of the conclusion that *Holoconops catawbae* is perhaps breeding sparingly along the shore of Lake Erie is the apparent suitability of the environment for its development. We have little information on the life history of Holoconops but Painter (1926) briefly describes larvae of *H. bequaerti* Kieffer which in Honduras are said to be found nearly always burrowing in wet sand mixed with a little humus along the edges of sea or brackish water; the larvae are recorded as often occurring in beach depressions which are wet but not disturbed by waves. The microscopic nature and burrowing habits of the larvae makes their detection most difficult but it is conceivable that they occur on sandy Lake Erie beaches. It should be emphasized, however, that such beaches are comparatively rare in the region in general. Predominantly there are limestone cliffs, shelves, and pebble beaches.

SUMMARY

1. A single female of *Holoconops catawbae* n. sp. was collected on a sandy Lake Erie beach in the act of biting viciously.
2. *H. catawbae* differs from its closest known relative, *H. kerteszi*, in the following respects: the last palpal joint is stalked and distinctly clavate, the penultimate joint has the pore distinctly distad of the middle, and the antepenultimate joint is subspherical; the body is reddish brown, the legs light brown; veins R_5 and M_{1+2} are subparallel or slightly divergent apically; total length 1.2 mm.; wing length 0.82 mm.
3. Suitability of the environment makes it seem possible that *H. catawbae* is breeding to some extent in the Lake Erie region.

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THE INSTARS OF PHYMATA AND SINEA (PHYMATIDAE, REDUVIIDAE: HEMIPTERA)[1]

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INTRODUCTION

The data on instars presented below were secured as by-products of my study of the weight patterns of *Phymata pennsylvanica americana* Melin and *Sinea diadema* Fabr. in relation to differences in the amounts and kinds of food administered. These studies extended over the years 1942 to 1945. The bugs were caged and fed individually, and kept at 80° Fahrenheit and approximately 80 per cent relative humidity. In this manner, I reared 14 series of *Phymata*, which yielded 176 adults—100 males and 76 females; and 19 series of *Sinea*, from which 127 males and 90 females were secured. Many other individuals failed to become adults, due to insufficient food and to accidents in molting or handling.

The tabulated data, given below, concern the duration of (a) the five instars that usually compose the nymphal stage of these predatory bugs, and (b) the nymphal stage as a whole. Duration in each species is stated in two forms, first (Tables I and II) in terms of days, both the average and the extreme numbers being given, and second (Tables III and IV) in terms of per cents that express the relative value of each instar in the total nymphal period. The durational records for the individual bugs on which these averages, extremes and per cents are based were taken daily, not hourly, as should perhaps have been done. As a result, the records contain errors varying from one to 24 hours. However, some records were quite precise because they chanced to be taken when the bugs were exuviating.

The series of *Phymata* and *Sinea* are arranged in the tables on the basis of the over-all duration of the nymphal life, the shortest being placed first, followed by the successively longer series. This gradation is correlated, in a cause-effect relation, with the amount of *Drosophila melanogaster* L. and *Musca domestica* L. permitted in the plans of the feeding experiments previously reported in other articles. That is, the more adequate the diet, the more rapid or the shorter the nymphal development. In the case of *Phymata* series number 7 (Table I) miscellaneous insects swept from vegetation in the field were substituted for *Drosophila* and *Musca*.

DISCUSSION

The tabulated data afford a basis for consideration of four aspects of instars. First to be treated is the variability in duration of (a) any one instar and (b) the entire nymphal stage under differing amounts of diet but somewhat uniform temperature and humidity. Reference to Table I will show that the total nymphal life of *Phymata* varied from 34 to 185 days, while the five instars exhibited spreads of 6 to 25, 5 to 34, 5 to 58, 6 to 39, and 8 to 34 days, respectively. The total nymphal life of *Sinea* (Table II) varied in length from 28 to 108 days, while the five instars ranged from 5 to 18, 4 to 13, 4 to 21, 5 to 33, and 7 to 48 days, respectively. It will be noted that the spreads given for *Phymata* are decidedly more extreme than those for *Sinea*. However, these figures are not to be accepted as signifying the full potential innate capacities for variation in the two species. They only reflect the ranges obtained incidental to my experiments under unequal dietaries. It may be stated with certainty that *Sinea* could be made to vary much more extensively than the above numbers indicate, if determination of its ability to vary were made the prime object of future experiments. Moreover, it is probable that *Phymata* could effect a greater range in time of development if tested further, particularly under a variety of temperatures.

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[1] Contribution No. 279 from the Entomological Laboratories of the University of Illinois. Supporting funds were appropriated by the Research Board of the Graduate School.

TABLE I

THE INSTARS OF *Phymata*. DURATION IN DAYS

	ADULTS REARED		AVERAGE AND EXTREME DURATION IN DAYS							
SERIES	Males	Females	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage	Nymphal Males	Nymphal Females
1	7	3	7 40 6–8	5 50 5–6	5.60 5–7	7.00 6–8	10.90 10–12	36 40 34–41	35 86 34–38	37.66 34–41
2	11	7	10.28 8–16	6.55 5–10	6.50 5–8	7.00 6–8	10.55 10–12	40.88 36–48	40.45 36–42	41 57 38–43
3	4	3	7.43 7–9	5.71 5–7	6.43 5–8	7.43 7–8	14.86 13–16	41.86 37–44	41.25 37–44	42.66 41–44
4	8	5	10.15 7–14	6.38 4–8	6.15 5–7	7.31 6–8	12.92 11–14	42.91 35–48	42.50 35–48	43.60 43–48
5	15	3	10.61 7–15	7.11 5–10	6.28 5–8	7.33 6–11	10.61 9–13	41.94 36–48	42.00 36–48	41.67 41–43
6	15	5	9.70 8–14	8.20 5–11	5.70 5–6	7.25 6–9	12.00 10–14	42.85 39–47	41.87 39–45	45.40 44–47
7	7	9	10.50 6–16	7.00 5–11	6.88 5–9	8.56 7–17	11.44 8–14	44.38 38–56	44.29 41–48	44.66 38–56
8	6	6	12.08 9–14	7.50 5–10	7.66 6–10	8.50 7–10	13.00 11–16	48.74 43–56	48.00 43–56	49.17 45–52
9	8	7	11.21 9–13	7.73 7–9	7.60 6–10	9.47 8–11	13.80 10–17	49.81 46–56	48.50 46–52	51.43 47–56
10	5	7	14.75 11–19	8.91 7–11	9.08 8–11	9.50 8–12	15.33 14–16	57.57 53–67	56.60 55–58	58.28 53–67
11	6	7	15.16 9–24	10.23 6–14	13.07 9–11	11.62 10–13	11.77 16–23	61.85 58–78	66.33 58–78	67.14 62–77
12	5	5	16.20 12–20	15.40 10–22	14.70 12–16	18.60 14–22	23.30 18–28	88.20 79–103	85.40 79–92	91.00 85–103
13	3	8	20 27 13–25	23.20 12–37	27.82 20–40	26.36 16–42	40.54 32–63	138.19 114–176	133.67 121–152	139.88 117–176
14	0	1	20.00	34.00	58.00	39.00	34.00	185.00	....	185.00

The second aspect concerns the differences in duration of growth between the two sexes of the species. With several exceptions in the case of *Sinea*, the reared series of the two bugs indicate that the females required a significantly greater number of days for their total nymphal growth, and therefore also for the several component instars, than the males (Tables I and II). This intersexual difference in time required to attain adulthood appears to be hereditary and

TABLE II

THE INSTARS OF *Sinea*. DURATION IN DAYS

	ADULTS REARED		AVERAGE AND EXTREME DURATION, IN DAYS							
SERIES	Males	Females	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage	Nymphal Males	Nymphal Females
1	8	3	7.18 5–9	4.36 4–5	4.36 4–5	5.73 5–68	8 36 8–9	30 00 28–33	30.1 28–31	29.7 29–30
2	4	5	8.10 7–9	4.44 4–5	4.77 4–7	5 77 5–9	9.33 9–11	32.41 30–41	31.00 30–34	33 60 30–41
3	6	3	8.66 6–12	4.77 4–6	5.00 4–6	6.11 5–10	9.11 8–11	33.65 29–41	35.00 29–41	31 00 29–32
4	8	7	7.53 6–9	5.40 4–8	4.93 4–6	6.27 5–12	9.60 7–18	33.73 28–51	31.13 28–36	36.71 31–51
5	7	8	7.53 6–9	5 73 4–7	5.40 4–8	6 86 5–15	9.80 8–13	35.32 30–51	35.14 30–48	35 50 30–51
6	4	4	6.87 6–9	6 00 5–7	5.75 4–8	6.87 6–10	10.25 8–21	35.74 30–51	36.25 30–51	35.25 33–37
7	10	4	8.00 6–12	5.36 4–8	5 21 4–6	6.64 5–12	11.21 9–25	36.42 29–58	36.7 29–58	35 75 33–39
8	8	6	8.50 6–15	5.50 5–8	5 36 4–7	6.64 5–11	12 86 8–31	38.86 30–64	40.50 30–64	36 66 31 46
9	7	2	7.22 6–9	6.11 4–8	6.22 4–8	8 44 6–14	13.33 8–25	41.32 30–58	43 86 35–58	41 50 30–53
10	10	4	10.43 8–17	7.79 6–9	5 86 5–7	9.21 6–15	12.50 8–19	45.79 37–60	47.30 39–60	42.00 37.46
11	7	7	9.43 5–13	7.50 5–10	6.14 5–8	8.64 5–16	14.71 9–26	46.42 30–63	41.86 30–51	51 00 39.63
12	13	6	10.53 7–15	7.15 4–9	6 26 4–10	8 79 5–13	13.89 8–31	46.62 32–69	43.92 32–55	52 50 46–69
13	8	8	10.10 7–12	7.25 6–8	6.25 5–8	10.00 5–16	14 12 9–22	47.72 35–60	46.25 35–60	49 25 44–58
14	9	9	11.55 9–18	7.61 5–9	6.17 5–7	9.94 7–12	16.67 11–24	51.94 46–58	50.67 46–58	53.20 48–55
15	2	2	6.00 5–7	8.00 7–9	10.00 8–12	14.00 11–21	18.25 13–24	56.25 49–72	50.00 49–51	62 5 53–72
16	1	0	11.00	8.00	14.00	7.00	22.00	62.00	62.00	00 00
17	10	1	10.18 8–12	9.09 7–12	10.82 9–14	15.36 10–22	25.36 15–40	70.81 52–95	70.60 52.95	63 00 ....
18	2	4	11.00 9–14	8.40 5–11	13.00 7–18	16.80 11–22	21.00 19–23	70.20 55–82	55.00 55–55	80.30 79–82
19	3	7	12.10 10–16	10.30 8–13	12.40 5–21	19.80 10–33	27.00 19–48	81.60 50–108	80.33 64–89	82 14 59–106

associated with the normal difference in bodily bulk, the females of both species being the larger. The data for *Phymata pennsylvanica* are to be taken as the more nearly correct, for the reason that the performance of this species is more nearly normal in captivity than that of *Sinea*, *Phymata* being decidedly more efficient in capturing both the small *Drosophila* and the larger *Musca*, and therefore comes closer to realizing its inherent potentialities for growth.

TABLE III

Phymata. Duration of Instars, in Per Cents

Series	What Per Cent Each Instar Contributes to the Duration of the Entire Nymphal Life				
	First	Second	Third	Fourth	Fifth
1	20.35	15.11	15.38	19.23	29 95
2	25 14	16.02	15.90	17.12	25.80
3	17 75	13 64	15.36	17.75	35.49
4	23 65	14.87	14 33	17.03	30.11
5	25 27	16 95	14.91	17.48	25.30
6	22.63	19.14	13.30	16.92	28.00
7	23 62	15.77	15.50	19.29	25.78
8	24 78	15.38	15.72	17.44	26.67
9	22.51	15.52	15.26	19.01	27.71
10	25.62	15.48	15.77	16.50	26.63
11	24.51	16.54	21.46	18.72	19.30
12	18.37	17.46	16.66	21.09	26.42
13	14.67	16.79	20.13	19.08	29.34
14	10 81	18.38	31 35	21.08	18.38

TABLE IV

Sinea. Duration of Instars, in Per Cents

Series	What Per Cent Each Instar Contributes to the Duration of the Entire Nymphal Life				
	First	Second	Third	Fourth	Fifth
1	23.93	14 53	14 53	19.10	27.87
2	24.99	13.70	14.71	17.80	28.79
3	25.73	14.17	14.86	18.16	27.07
4	22.32	16.01	14.61	18.59	28.46
5	21.32	16 22	15.29	19.42	27.75
6	19.22	16.79	16.09	19.22	28 68
7	21.97	14 72	14.31	18.23	30.78
8	21 82	14.15	13.79	17.09	33.09
9	17.47	14.78	15.05	20.42	32.26
10	22.78	17.01	12.79	20.12	27.30
11	20.31	16 16	18.23	18.61	31.69
12	22.59	15.34	13.42	18.86	29.79
13	21.16	15.19	13.10	20.95	29.59
14	22.24	14.65	11.89	19.14	32.09
15	10.66	14.22	17.78	24.89	32.44
16	17.74	12.90	22.58	11.29	35.48
17	14.38	12.84	15.28	21.69	35.81
18	15.67	11.91	18.52	23.93	29.91
19	14.83	12.62	15.20	24.26	33.09

The third topic suggested by the tabulated data concerns the question whether the instars of these insects possess what may be described as an ideal durational pattern, and, if so, what are its characteristics? by "ideal durational pattern" I mean (a) the most rapid development on the one hand, and (b) the most prolonged development of which the species is capable under a given set of environmental and hereditary conditions. Such a pattern implies that not any one or two, but *all* the instars of the nymphal life are completed in (a) the least amount of time or (b) the maximum amount of time possible for the species. It represents, on the one hand, the irreducible minimum, and, on the other, the inextensible maximum time period in which the species can complete its growth from the event of hatching to transformation to the adult form. The value of the pattern is not fixed, set or absolute, for it changes with alteration of the environment, particularly food, temperature and relative humidity, and the peculiar combination of hereditary traits possessed by the individuals subjected to experimentation.

What actual values enter concretely into the composition of these ideal patterns of instars in the cases of *Phymata* and *Sinea?* Too few data are at hand to permit further consideration of the maximum pattern, which is secured by use of the most attenuated diet and the most adverse temperatures and humidities the species can tolerate and still grow to adulthood. However, the data provided in the most adequately nourished series of *Phymata* (Ser. 1, Table III) affords some idea of the features that possibly characterize the ideal minimum developmental pattern of this species. Expressed in terms of per cents and round numbers, this pattern is 20, 15, 15, 20, and 30 for the five instars, respectively. Here the first and fourth instars are of equal duration, as are also the second and the third, while the fifth is equal to the second and the third combined, and one-half longer than either the first or fourth.

It will be observed from series 1 to 6, Table IV, that the minimum pattern for *Sinea* conforms in some respects to that of *Phymata* just described, but differs from it in others. While the second and third are approximately equal and also the shortest of the five instars, and the fifth required about as much time as the second and third combined, the fifth is relatively shorter than either the first or the fourth. Are these differences between the minimum patterns of the two species inherent and characteristic, or are they results of unequal dietaries? I am inclined to the latter view for the following reasons.

First, the proportionately greater duration of the first instar of *Sinea* may arise from a degree of ineptitude in capturing *Drosophila* and also may be due to a supply of nutrient known to be carried over into the nymph from the egg, and which effects a delay in growth and thus a prolongation of the instar. On the other hand, the relatively greater length of the fifth instar is probably the result of (a) the inability of the nymphs in that stadium to secure enough *Drosophila* and (b) their disposition to avoid the boisterous *Musca*, with the consequence that *Sinea* fails to ingest sufficient food to meet its needs for maximum growth and to realize its ideal time pattern under the captive conditions imposed.

The fourth feature of instars indicated by the tabulated data relates to the number of instars that composes the total nymphal stage. In the course of rearing 393 adult bugs individually, I had an opportunity to determine the number of growth periods with considerable precision. Despite the extreme variation secured in length of nymphal stages due to the great range of dietary imposed on the several series of *Phymata* and *Sinea*, only one individual positively departed from the usual number of five instars by adding a sixth. The exception was a male *Sinea* that was provided a maximum number of *Drosophila* each day throughout his nymphal life. The duration of the total nymphal period was not significantly increased by the added instar, it being 49 days. Seven other males, of the same series and dietary, completed their five instars in an average of 44 days, with extremes of 35 and 58. That is, the addition of an instar had the effect of abbreviating the inter-molt periods rather than increasing the length of the over-all nymphal stage.

In conclusion, I should like to suggest further studies on the question of insectan instars. Does the pattern generally follow a common design, in which the first and last instars are longer than the intermediate ones? What underlying structures or processes, possibly such as cuticular characters, glandular functions, cell division and rate of ingestion, determine the relative per cent of time each instar consumes in the course of nymphal growth?

HONORING PROFESSOR WILLIAM A STARIN

Doctor William A Starin of the Ohio State University, Department of Bacteriology, will retire from active service at the end of this academic year after 38 years of teaching in the Department. Plans are being made by friends and former students to honor him on this occasion, and a sincere effort is being made to reach all who might wish to have a part in these plans. Letters are being sent to those for whom addresses are known, and it is hoped that those who do not receive letters will take this notice as a personal invitation to participate in the program so far as is possible. There are two important parts of the program to be noted:

First: The William A. Starin Lectureship has been established through the Ohio State University Development Fund and will be administered by the Department of Bacteriology in consultation with the Dean of the Graduate School. All of Doctor Starin's friends and former students who can be contacted are being asked to send such contributions as they desire for this fund. The money will become part of the University's permanent endowment and will, it is hoped, yield an income sufficient to provide an annual speaker. Checks should be made payable to the Ohio State University Development Fund.

Second: A dinner in Doctor Starin's honor is being arranged for Saturday, May 8, at the Neil House in Columbus, and all friends and former students who can do so are invited to attend. It is important that tentative reservations be made immediately. Definite reservations must be made by May 1.

Checks for the Lectureship, and reservations for the dinner should be sent to Dr. Margaret D. Heise, Department of Bacteriology, Pharmacy and Bacteriology Bldg., Ohio State University. For further information, please call or write Dr. Heise, or Marian Estep, Department of Physiology, Hamilton Hall, Ohio State University.

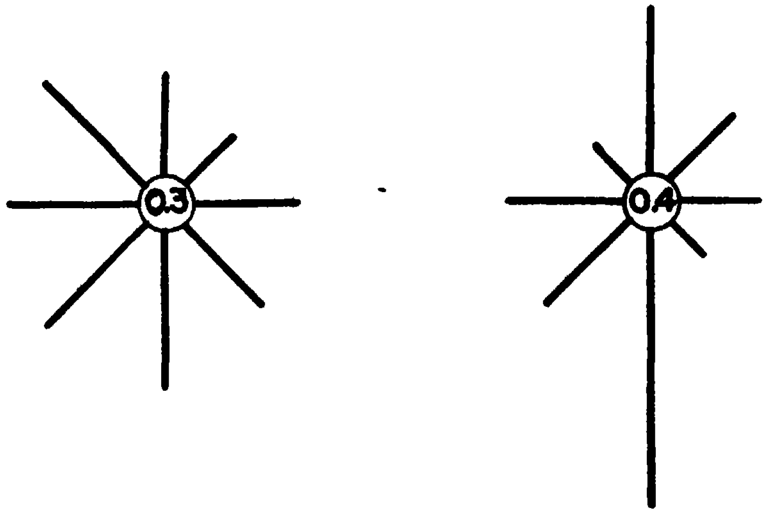
WIND DIRECTIONS

F. A. CARLSON,
Department of Geography,
The Ohio State University

In the middle latitudes of the northern hemisphere, extending approximately from 40° north latitude to the subpolar lows in the vicinity of the Arctic Circle are the so-called Prevailing Westerlies or Southwest winds. The air moves out of the poleward areas of the subtropical regions of high pressure toward the subpolar lows and due to the earth's rotation the winds are deflected as they move into the higher latitudes, becoming southwest winds in the northern hemisphere and northwest winds in the southern latitudes. The Westerlies are a part of the well-known and often misapplied Planetary Wind system, or general air curculation of the earth. This general circulation system must be considered only as a background upon which more varied patterns of air movements take place. The practice on the part of some earth scientists to refer to the General Circulation as primary and all other air movements such as air masses, monsoons, local winds and the like as secondary is hardly in accordance with their relative significance, particularly, when reference is made to surface winds. The diversification and complexity of the factors affecting air movement are so great that any generalization has comparatively little importance.

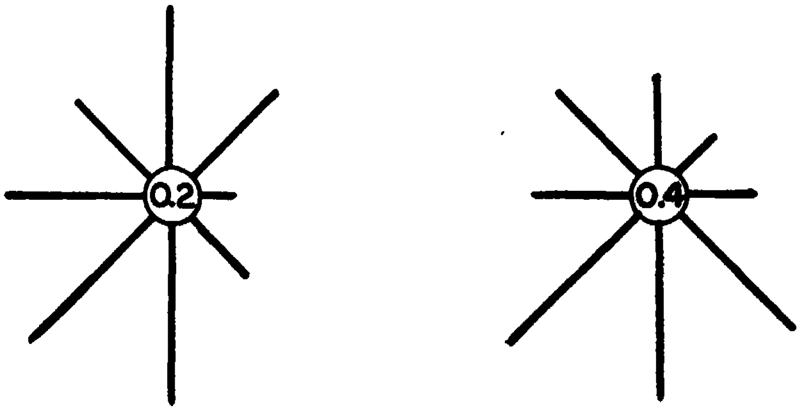
The accompanying graphic representations of wind directions, the Wind Roses (Figs. 1–2), do reflect the principles of the Earth's general circulation; however, the fact that there are other influences, or disturbances, is equally in evidence. Local conditions, the degree of exposure and elevation of recording instruments are clearly represented in the Columbus Wind Roses (Fig. 1). When the Weather Station was located on Broad Street, the records of wind direction for the period 1918–1930, show a high prevalency of westerly winds. Later, when the station was moved to Marconi Street, the records for the years 1935–45 disclose that the predominant wind direction is south. The difference is undoubtedly due, primarily, to local circumstances. The recording instruments at the Broad Street location were 239 feet above ground (surface elevation 760 feet above sea-level) whereas the present Marconi Station wind meters are 110 feet above the street level (surface elevation 724 feet above sea-level). Furthermore, the Marconi Street Station has less free exposure than the former Broad Station. It may also be added that the wind velocity average is less at the lower elevation, namely, the Marconi Street position, than at the former Broad Street Station. In all probability, the difference in the records of the two Cleveland Stations (Fig. 1) likewise are indicative of difference in local conditions.

These preliminary notes, concerning wind directions in Ohio, have been made in full recognition of the Significance of the Earth's general air circulation as well as to emphasize the equally important but often misplaced and misnamed secondary air movements.



COLUMBUS, OHIO
BROAD STREET
1918 - 1930

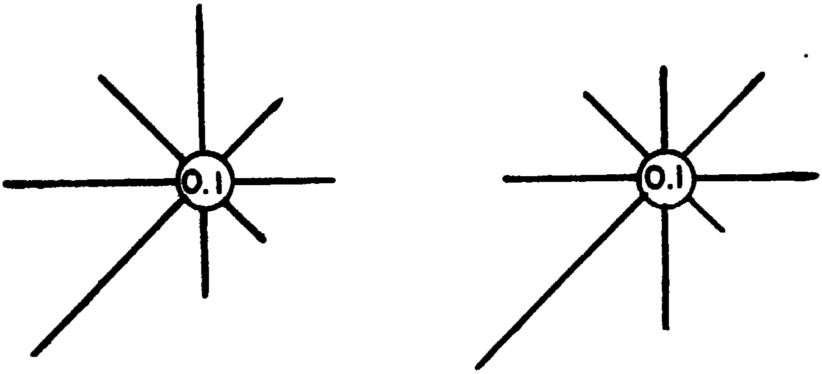
COLUMBUS, OHIO
MARCONI STREET
1935 – 1945



CLEVELAND, OHIO
DOWNTOWN
1890 - 1930

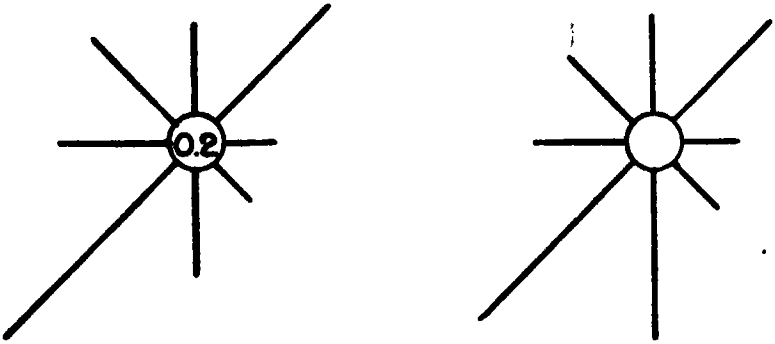
CLEVELAND MUNICIPAL
AIRPORT
1942 - 1945

Fig. 1. Wind Roses.



TOLEDO, OHIO
1918-1945

SANDUSKY, OHIO
1931-1945



VANDALIA, OHIO
DAYTON MUNICIPAL AIRPORT
1943-1945

CINCINNATI, OHIO
ABBE OBSERVATORY
1929-1938

Fig. 2. Wind Roses.

NEW GENUS AND SPECIES OF CERAMBYCIDAE WITH NOTES (COLEOPTERA)

J. N. KNULL,
Department of Zoology and Entomology,
The Ohio State University

Romulus n. g.

Head convex, concave in front; base of antenna partly enveloped by coarsely granulate eye, segments three to eleven inclusive somewhat flattened, sensory areas forming carinae on outside of last six segments, apices of segments three to six inclusive angulate on inside giving faint indication of spines.

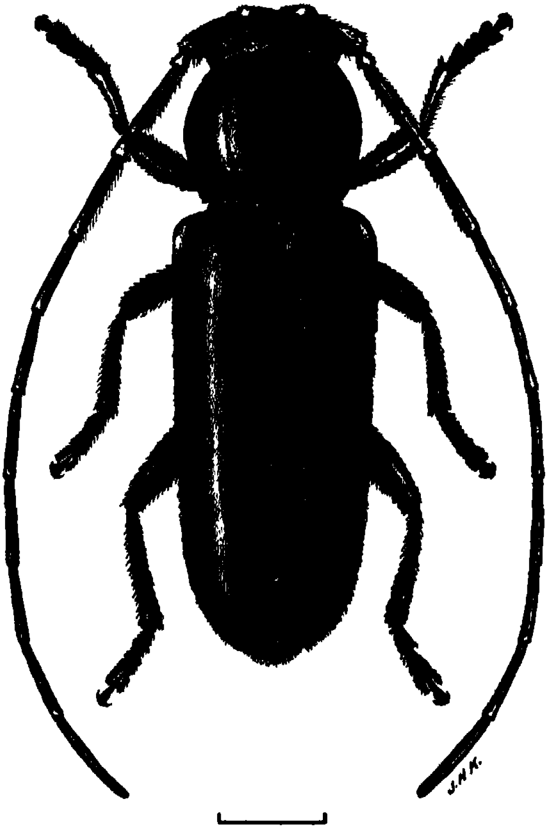


Fig. 1. *Romulus globosus* n. sp. Line equals 5 mm.

Prothorax globose; disk of pronotum convex with median depression at base and two slight elongate, pubescent depressions each side at about middle.

Elytra at base wider than widest part of pronotum; apices emarginate, forming angle on each side of emargination.

Anterior coxal cavities open behind, middle coxal cavities closed behind. Metathoracic episterna narrowed posteriorly. Legs stout.

Genotype: *Romulus globosus* n. sp.

This genus should be placed in Phoracanthini next to *Romaleum*. In male it differs from this genus by globose, smooth pronotum, lack of definite spines on antennae or elytral apices.

Romulus globosus n. sp.

Male: Robust; color dark reddish brown, head and prothorax darker; pubescence short, inconspicuous.

Head finely, densely punctured; antennae extending over two segments beyond apices of elytra, scape stout, second segment as long as wide, third longer than scape, fourth shorter than third, fifth to ninth inclusive about equal to third, tenth shorter than ninth, eleventh equal to third.

Pronotum globose, widest in middle, sides broadly rounded from base to apex, disk convex; surface more finely and densely punctate than head. Scutellum obtusely angled in rear.

Elytra at base wider than widest part of pronotum; sides subparallel in front, broadly rounded to apices from about middle.

Abdomen beneath more densely pubescent, finely densely punctate; last visible ventral segment broadly rounded.

Length 29 mm.; width 9.5 mm.

Holotype male labeled Coral Gables, Fla., May 20, 1943, H. Conger collector. Paratypes, same locality, May 10, 1929; Ocala National Forest, Fla., July 27, 1938, Hubbell and Friauf, all in collection of author. Paratype from Crescent City, Fla., Hubbard and Schwarz, in U. S. National Museum.

The author is indebted to Dr. H. F. Strohecker for material and to Mr. W. S. Fisher for loan of material and comparison with West Indian species.

Elytroleptus ignitus Lec

Adults were taken from foliage of large oak tree on July 16, 1937, in Huachuca Mountains, Ariz., where they were associated with *Lycostomus femoratus* Schffr., which they closely resemble. It was extremely difficult to pick active cerambycids from the large number of lycids which fell into umbrella at same time. Other trees in immediate vicinity did not yield material.

Neoptychodes trilineatus var. **insularis** (Fairm.)

Breeds in bases of living willow (*Salix* sp.) in Chiricahua Mountains, Ariz.

Tetraopes discoideus Lec.

Taken on low milkweed, May 25–31, 1939, at Brownsville, Tex.

SOME ALGAE FROM THE BLACK HILLS OF SOUTH DAKOTA AND THE TURTLE MOUNTAIN REGION OF NORTH DAKOTA[1]

CLARENCE E. TAFT,
The Ohio State University, Columbus, Ohio

During June, 1939, the writer came into possession of a series of algal samples collected by Dr. R. T. Wareham, of the Botany Department, The Ohio State University. The first eight in the series were from the vicinity of Spearfish in the Black Hills of South Dakota. Representative of stream habitats, these were the least interesting of the series, both in number and variety of species. The remaining twenty collections were from the Turtle Mts. of North Dakota in the vicinity of Bottineau, Lake Metigoshe, Dunseith, and Boundry Butte. These were of decided interest and were characteristic of the northern bog-lake areas in which desmids predominate.

The most comprehensive account of the algae of North Dakota is found in two papers, one by Moore (1917) and the other by Moore and Carter (1923). The first was a study of the algae in Devil's Lake, while the second dealt with the algae in numerous lakes of northeastern North Dakota, including some of the area concerned in the present report. The main objective, as summarized in the second paper, was to contrast the algal flora of the "freshwater" and "alkaline" lakes. This paper listed a total of 148 named species and varieties with their distribution in the two types of lakes. Nine additional species and varieties recorded only from Devil's Lake (1917) increased the records to 157 for the region.

Of the 73 forms in the present report, 12 have been previously listed, and are designated by an asterisk The list, though not extensive, indicates that a study of the algal flora of the Turtle Mts. would be well worth the effort involved.

The writer wishes to thank Dr. Wareham for the time and effort expended in securing the collections.

SPECIES LIST

BLACK HILLS, SOUTH DAKOTA

Nostoc verrucosum Vauch.
Protococcus viridis Ag.
Ulothrix tenerrima Kütz.
Ulothrix zonata (Weber & Mohr) Kütz.
Cladophora glomerata (L.) Kütz.
Vaucheria borealis Hirn.
Closterium leibleinii Kütz.

TURTLE MOUNTAINS, NORTH DAKOTA

- Cyanophyta
  - *Chroococcus turgidus* (Kütz.) Näg.
  - *Chroococcus limneticus* Lemm.
  - *Microcystis incerta* Lemm.
  - *Aphanocapsa elachista* var. *conferta* W. & W.
  - *Aphanothece stagnina* (Sprengel) A. Br.
  - *Merismopedia tennuissima* Lemm.
  - *Nostoc commune* Vauch.
- Chrysophyta
  - *Dinobryon sertularia* Ehr.
  - *Ophiocytium arbusculum* (A. Br.) Raben.
  - *Tribonema utriculosum* (Kütz.) Hazen

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[1] Paper from the Department of Botany, The Ohio State University, No. 493.

Algae from South Dakota and North Dakota
Clarence E. Taft

PLATE I

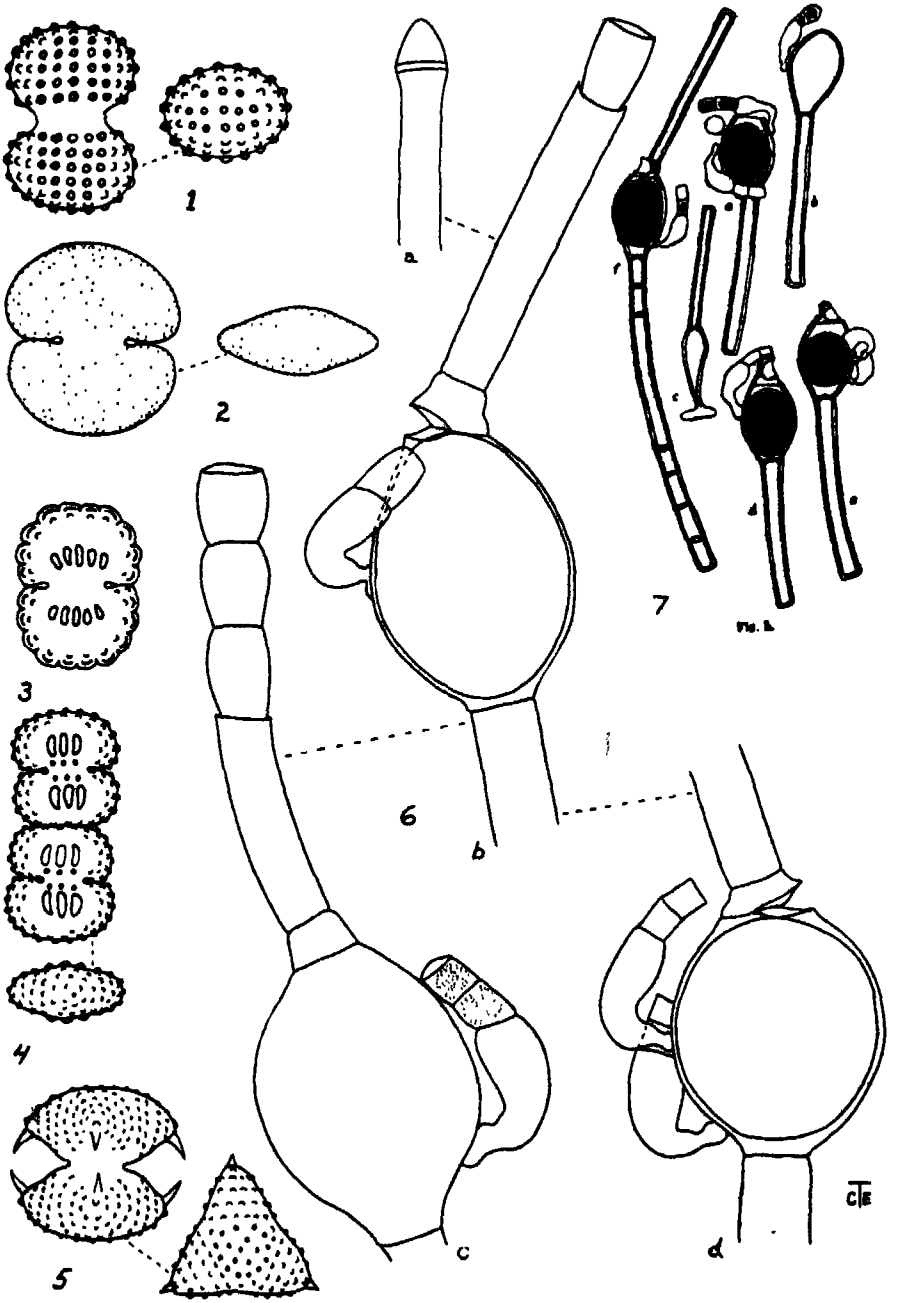

FIG. 1. *Cosmarium isthmium* West *forma*. FIG. 2. *Cosmarium lundellii* var. *corruptum* (Turner) W. & W. FIG. 3. *Cosmarium saxicolum* Kaiser. FIG. 4. *Cosmarium vogesiacum* Lemaire *forma*. FIG. 5. *Staurastrum dakotii* sp. nov. FIG. 6a-d. *Oedogonium koersholmiense* Hallas. A, apical cell; b, c, d, fruiting filaments with androsporangia and dwarf males. FIG. 7. *Oedogonium koersholmiense* Hallas. From the original figures by Hallas.

Chlorophyta
**Pandorina morum* (Müll.) Bory
**Eudorina elegans* Ehr.
Gloeocystis ampla Kütz.
Asterococcus limneticus G. M. Smith
**Cylindrocapsa geminella* Wolle
Stigeoclonium subsecundum Hazen
Microthamnium kuetzingianum Näg.
Microthamnium strictissimum Raben.
**Rhizoclonium hieroglyphicum* (Ag.) Kütz.
Oedogonium hoersholmiense Hallas. Figs. 6a-d, 7.

Veg. cell 8–16 x 68–160μ; oogon. 42–48 x 60–72μ; oosp. 39–45 x 42–46 (–58)μ; androsp. 13–19 x 16–21μ; dwarf male stipe 11–14 x 29–32μ; antheridium 9–11 x 9–16μ.

Lake Metigoshe, N. Dakota.

Oed. hoersholmiense appears to be a rarity. Tiffany (1930) lists its distribution as Denmark, where it was first described by Hallas (1905). Later (1937) Tiffany listed it as an extra-linital species in his work on the North American Oedogoniaceae. The North Dakota material has been assigned to this species with some trepidation although it agrees remarkably well with the figures published by Hallas. The dimensions, especially the breadth of the oogonia and oospores, are greater, but it is the writer's opinion that these are nearer the upper extremes for the species and therefore should be included in the description.

**Pediastrum boryanum* (Turp.) Menegh.
Pediastrum araneosum var. *rugulosum* (G. S. West) G. M. Smith
**Ankistrodesmus falcatus* (Corda) Ralfs
Tetraedron minimum (A. Br.) Hansg.
Scenedesmus armatus (Chod.) G. M. Smith
Scenedesmus arcuatus Lemm.
Scenedesmus acutiformis Schröder
**Scenedesmus obliquus* (Turp.) Kütz.
**Scenedesmus quadricauda* var. *quadrispina* (Chod.) G. M. Smith
Vaucheria hamata (Vauch.) D. C.
Spirogyra condensata (Vauch.) Kütz.
Spirogyra hassallii (Jenner) Petit
Cylindrocystis brebissonii var. *minor* W. & W.
Netrium digitus (Ehr.) Itzg. & Roth
Netrium digitus var. *naegelii* (Bréb.) Krieger
Pleurotaenium ehrenbergii var. *crenulatum* (Ehr.) Krieger
Closterium acerosum (Schrank) Ehr.
Closterium kutzingii Bréb.
Closterium moniliferum Näg.
Closterium parvulum Näg.
Euastrum abruptum Nordst.
Euastrum binale var. *hians* W. West
Cosmarium amoenum Ralfs
Cosmarium angulosum Bréb.
Cosmarium connatum Bréb.
Cosmarium impressulum var. *suborthogona* (W. & W.) Taft
Cosmarium isthmium West forma? Fig. 1.

L. 40μ, w. 29μ, isth. 14μ.

Somewhat more compressed in vertical view but in agreement with the material figured by Wailes (1931) from British Columbia.

Cosmarium lundellii var. *corruptum* (Turn.) W. & W. Fig. 2.

L. 41–43μ, w. 44–45μ, isth. 13–14μ.

The dimensions of this material are somewhat less than those by Turner (1892) and decidedly less than those by West & West (1905). If this variety as proposed by the Wests, is a complex of three of Turner's species and varieties, then a great variation in size may be expected. Listed here as var. *corruptum*, the material resembles *Cos. corruptum* Turner more than *Cos. subcirculare* var. *rugosum* Turner or *Cos. rotundatum* which the Wests maintain are parts of the complex.

Cosmarium obtusatum Schmidle

Cosmarium ochthodes Nordst.

Cosmarium punctulatum Bréb.

Cosmarium pyramidatum Bréb.

Cosmarium quadratum Ralfs

Cosmarium rectangulare var. *hexagonum* (Elfv.) W. & W.

Cosmarium saxicolum Kaiser. Fig. 3.

L. 30μ, w. 24μ, isth. 11μ.

The North Dakota material agrees very closely with Gronblad's figures (1932). The cells have less ornimentation and are smaller than those figured by Krieger (1938).

Cosmarium sexangulare Lund

Cosmarium speciosum Lund

Cosmarium subarctoum (Lager.) Racib.

Cosmarium subcucumis Schmidle

Cosmarium vexatum West

Cosmarium vogesiacum Lemaire forma? Fig. 4.

L. 24–26μ, w. 22–24μ, isth. 8–9μ.

This form differs from the species in having 3 parallel protuberances on the central face of each semicell. The dimensions are almost exactly those of the species as well as of var. *alpinum* (Schmidle) Laporte. (Laporte, 1931).

Staurastrum dakotii Taft sp. nov. Fig. 5.

Cells small, as broad as long, constriction deep, sinus opening wide; semicells roughly elliptic, apex depressed, margin granulate, lower margin rounded, smooth, slightly concave near the angles, angles truncate, each with a sharp, stout spine pointing downward, surface granulate, granules small and in series across the sides and top of the angles; vertical view triangular, sides slightly concave, wall granulate, granules in series across the angles, granules at center scattered.

L. 31–34μ, w. 31–33μ, isth. 9–10μ.

Boundry Butte, North Dakota.

The depressed semicells, absence of spines on the cell wall, and the truncate apices of the angles distinguish this species from *St. arnellii* var. *spiniferum* W. & W. (West & Carter, 1923). The type of granulation, the absence of verrucae, and the truncate angles separate it from *St. oxyrhynchum* Roy & Biss. (Roy & Biss, 1886).

Staurastrum hirsutum Bréb.

Staurastrum punctulatum forma? Boldt. (Boldt. 1888).

Hyalotheca dissiliens (Sm.) Bréb.

Hyalotheca mucosa (Mert.) Ehr.

Desmidium aptogonum var. *acutius* Nordst.

Desmidium swartzii Ag.

Euglenophyta

Euglena pisciformis Klebs

Euglena sanguinea Ehr.

Phacus pleuronectes (Müll.) Duj.

Phacus triqueter (Ehr.) Duj.

Trachelomonas volvocina Ehr.

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SOME PECULIARITIES OF THE MALE FROG TEST FOR EARLY PREGNANCY

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An article describing the use of the male of the leopard frog (*Rana pipiens*) as a new test animal for early pregnancy was published in *Science* for February 20, 1948 (1). This is a rather radical departure from the widely used effects of the gonadotropic hormones upon the female sex organs of test animals. In this new test we have described a method that has as its chief virtues accuracy, rapidity, sensitivity, and simplicity.

FIG. 1. Method of injecting into the dorsal lymph sac of a frog.

The simplicity of the technic is easily seen from the following description. The patient secures an ounce or more of the first urine she voids upon arising in the morning and sends this to the physician for the test. The technician injects, by hypodermic syringe, from 2 cc. to 4 cc. of the urine into the lymph sacs of a male frog using a 25 gauge needle. Larger needles may allow the urine to leak out. The frog is then placed in a pint fruit jar which has a wide mouth and a perforated lid. The jar is labelled and set aside for a period of from two to four hours during which the frog absorbs the urine. At the end of this period an examination of the jar will often show the presence of urine voided by the frog. If not, the frog may be made to urinate by seizing its head and shoulders in the hand whereupon the frog will reflexively eject a jet of urine. A drop of the voided urine is placed upon a microscope slide covered with a cover-glass and examined under 16 mm. and 4 mm. objectives. Since the spermatozoa of ***Rana pipiens*** are large the technician soon learns to recognize them with the 16 mm. lense alone. The presence of the frogs sex cells in the urine indicates a positive result of the test for the presence of the gonadotropic hormone usually found in the blood plasma of pregnant women.

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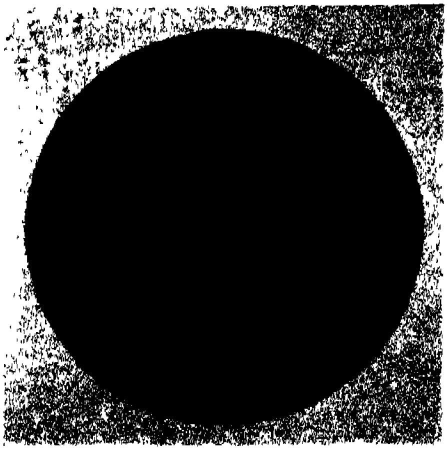

FIGURE 2

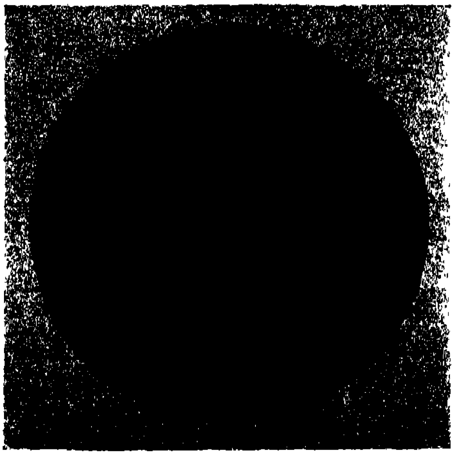

FIGURE 3

FIG. 2. Photomicrograph of a drop of frog urine containing frog sperm cells, as seen when using 10× ocular and 16 mm. objective.

FIG. 3. Photomicrograph showing frog sperm cells as seen when using 10× ocular and 4 mm. objective. Cigar-shaped bodies are sperm heads each of which bears a transparent flagellum at one end. There are eight sperms appearing in this illustration.

The absence of the frog sperm cells is a negative result of the test for the hormone. Since the activating agent *seems* to be chorionic in origin its presence in the urine of the women should ordinarilly indicate pregnancy. R. G. Hoskins (2) says that the placenta "apparently also functions as an endocrine gland producing important regulatory hormones. Concentration of the urine insures greater certainty of the results and the use of fewer frogs.

CARE AND HANDLING OF THE FROGS

The leopard (or grass) frog is widely distributed and may be bought from frog farms, biological supply houses, or collected locally. The ideal time to collect them seems to be in early autumn before cold weather has brought on hibernation The testes of such frogs contain mature sperms. They may be kept best in a cold storage room in which the temperature never gets below freezing, from 34° to 40°F. They should be placed in a box of damp peat moss and sprinkled lightly whenever they seem to be getting dry. If a few frogs are brought out of this storage one or two days before they are used in tests they can be kept in a wet place until used. Frogs should be wet at all times but ***not kept in water from which they cannot crawl out.*** In deep water a frog will drown. A very satisfactory container is a pan or tray 4 inches deep by 18 inches wide by 30 inches long. It should be covered with a lid of half-inch mesh woven-wire so hinged that each end of the lid may be opened without opening the whole top of the pan. Such a pan will hold up to 100 frogs to start. If the pan is tilted so that water will stand in one end while the other is free from water the frogs can keep wet by getting into the water. If the water is not running it should be changed every day. Frogs that are cool will keep for weeks without feeding. Small crayfish, earthworms or mealworms can be fed if the frogs are not in storage, but this is hardly necessary.

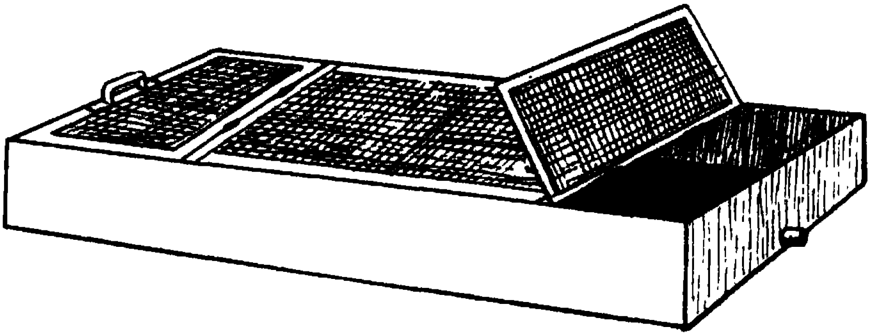

FIG. 4. Tray for keeping a stock of 100 or less frogs.

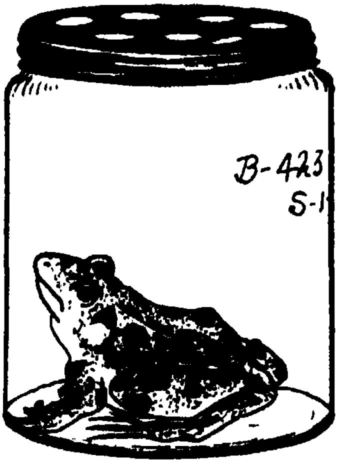

FIGURE 5

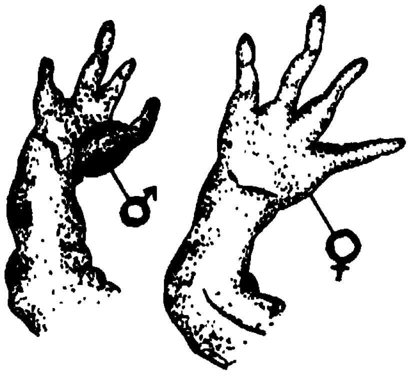

FIGURE 6

FIG. 5. Wide-mouthed pint fruit jar with perforated metal lid for holding individual frogs during test.

FIG. 6. Male frogs are distinguished from females by swollen base of "thumb."

If a frog has been used in a test and the test was negative, that frog may be returned to the original pan and used over again at any time. But *if the test was positive* the frog should be placed in another container for at least four days before being reused. Hence two pans should be provided as containers. For the individual physician who wishes merely to run an occasional test for a patient it is possible to have half a dozen frogs which can be kept in a large jar with a heavy screen top. A very thin layer of water in the bottom of the jar is sufficient and this should be changed daily.

In this species of frog (*Rana pipiens*) the sexes are easily distinguished by the difference in the appearance of the base of the first digit (thumb) on the foreleg. It is generally swollen and more heavily pigmented in the male as shown in figure 6. The body of a mature frog of this species should be from two and a half to three and a half inches in length. Orders to supply houses or collectors should specify "males only", and even then the technician should *carefully check each frog* when it is selected for a test.

The skin of the frog is very loosely attached to the body wall, being fastened by strips of connective tissues which divide the space between the skin and the muscles into large pockets, or lymph sacs. In making an injection the needle should be thrust through the skin but not into or through the body wall. Interperitoneal injection can be made but is likely to result in severe injury to the frog. During the injection it is best to hold the frog by its hind feet. The frog will straighten out on the table top and does not struggle much during injection. A check on each frog can be made by placing it in a jar for an hour before it is injected. At the end of this time its urine can be examined for sperm cells. It must be negative. Then the frog may be injected for the test, each frog furnishing its own check. We have always recommended that two frogs be run for each test as a precaution against individual differences or in the case where the potency of the hormone is low.

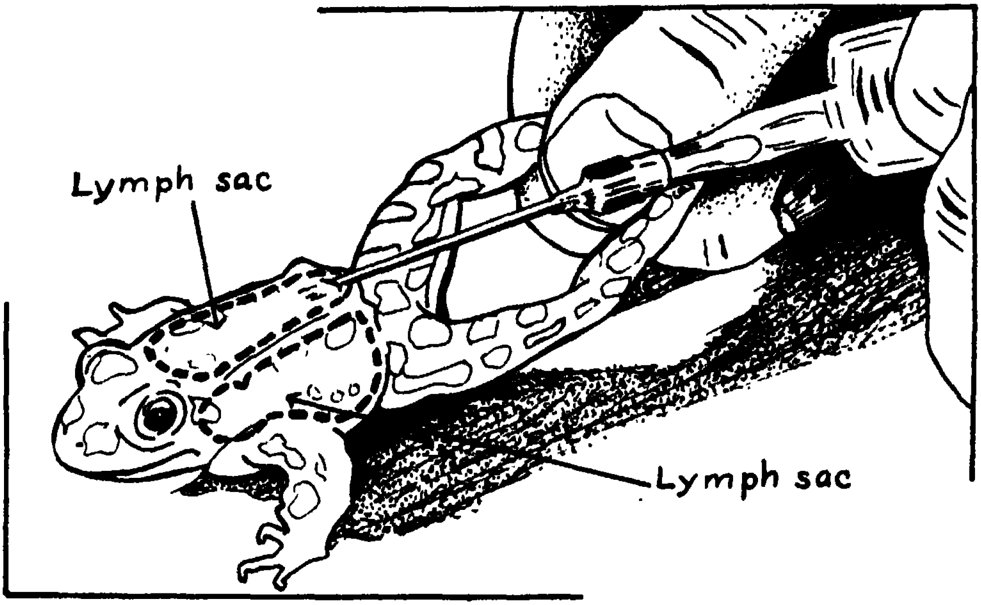

FIG. 7. Showing dorsal and lateral lymph sacs.

SOME PECULIARITIES AND RESULTS OF THE TESTS

Samples of pregnancy urine may be kept and used for demonstration purposes or for producing live spermatazoa for classroom study. One sample of such urine was kept in the refrigerator for five weeks and then gave a good positive test. The same sample after standing at room temperature for six more days still gave as good a test when fresh. Another sample was kept for several days at room temperature and then preserved by adding two drops of toluene and shaking thoroughly. After standing at room temperature for eight weeks it produced a strong positive test. This seems to indicate that the *gametokinetic substance* does not deteriorate readily. However, some of the commercially prepared anterior petuitary-like substances degenerate rapidly when opened to the air. The commercially prepared substance will give a heavy discharge of sperm cells if they are used in fresh condition. A sample of urine known to give a strong positive test can be kept and used upon a male frog at any time that living sperm cells are needed for teaching purposes. These large sperms make excellent demonstration material and may be obtained so much more readily than from mammals. Being fresh they are better teaching materials than a stained smear which is so often used. Urine for this purpose cannot be preserved by heating as heating to the boiling point destroys the effectiveness of the urine.

In a few cases we have found that a urine sample is very toxic to the frogs causing death too early to get a test. In these it has been possible to get a successful test by gradual dilutions of the urine and by watching the test animals so as to collect a urine specimen from them before death. As small a sample as 0.5 cc. of pregnancy urine diluted to 2.0 cc. with tap water has been successful in getting a positive test in some such instances. Adjusting the pH to neutrality is also helpful.

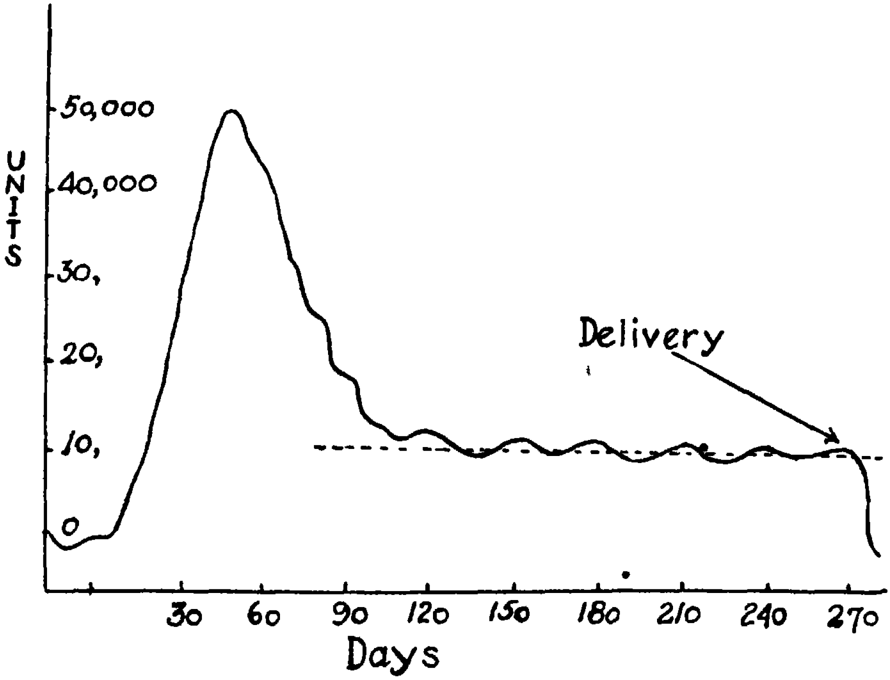

FIG. 8. A composite graph of the abundance of gametokinetic substance in urines during pregnancy. Not taken from any particular study.

In one case of uncertain pregnancy we obtained a urine sample and blood sample at the same time. The urine sample gave a positive test when run with a frog. The blood serum was used upon another frog in the same manner as urine and produced a similar positive test. In another case a women who had recently missed a menstrual period was being given a Friedman test to determine whether she was pregnant. We secured a sample of urine and ran a frog test simultaneously. The frog test was positive, the Friedman test was negative. Ten days later a second Friedman test gave a positive result. Parallel series are being run in several laboratories now.

During our very early studies we expected to accumulate a large number of positive tests in a short time by testing known late pregnancies. We ran 32 tests in one day and found to our dismay that half of them gave negative results. This looked as if the test was not accurate and we were about to discontinue it when we recalled that studies on blood of pregnant mares and women had shown that the gonadotropic hormone increases very rapidly from conception to 30 days, decreases rapidly up to 90 days, and then continues at a low level around the threshold until delivery, at which time it seems to disappear. All of our tests made during the first trimester of pregnancy had given positive tests. This fact correlated with the abundance of the hormone in the blood during the first 90 days. During the third trimester the level of the hormone was so low that it might be above or below the threshold of sensitivity of the frog. We have tested a few cases during late pregnancy of women whose cycle was regular and who had accurate knowledge of dates and we found that the urine sample taken at the time when menstruation would have occurred gave very weak positive or even negative tests; whereas urine samples taken from the same women between menstrual dates gave strong positive results. This explained our 50 per cent false negatives in the last trimester. It seems that even though the woman is pregnant and bleeding does not occur, there is a lessening of the effect of the gonadotropic hormone during the period when menstruation would have occurred if she were not pregnant.

When testing an extremely early pregnancy, as ten days to two weeks, the number of sperm cells may be very few as compared with 30 days and a recheck should be made one week later which will usually give a strong reaction. It must be remembered, however, that the smaller number of cells is just as positive a test as a larger number. There is no such thing as being *slightly* pregnant.

Further clincal applications of this test are its use in abortions and missed abortions. Our first case was a natural miscarriage. A urine sample taken 6 hours after delivery of the foetus proved positive *indicating that the placenta was still adhering to the wall* of the uterus. Dilation of the cervix proved this to be true. The placenta was removed and a test of a urine sample taken 18 hours later gave a negative result. In the case of suspected missed abortions, where the placenta and uterine wall separate but delivery of the foetus does not follow, the frog test can indicate whether the separation has occurred or not. If the test is positive the placenta is still attached and alive. If the test is negative the placenta has separated, the child is dead and the undischarged mass can be removed. We hope to report more detailed information soon concerning clinical applications in therapeutic and pathological situations.[1]

REFERENCES

(1) **Wiltberger, P. B.** and **D. F. Miller**, "The Male Frog, *Rana pipiens*, as a New Test Animal for Early Pregnancy." *Science*, February 20, 1948, Vol. 107, No. 2773, p. 198.

(2) **MacLeod's** "Physiology in Modern Medicine." C. V. Mosley Co., 1941, Ch. LXXVI; p. 1051.

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[1] Since this paper was prepared the following article has been published on some clinical applications of the Asheim-Zondek test:

ZONDEK, BERNHARD; FELIX SULMAN, AND RYVKA BLACK. "Hormonal Test for Foetal Death." *Jour. A. M. A.*, Vol. 136, No. 15, p. 965, Apr. 10, 1948.

PETROLEUM GEOLOGY IN THE UNITED STATES GEOLOGICAL SURVEY[1]

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U. S. Geological Survey, Washington 25, D. C.

The drilling of wells in the United States for natural gas began in 1821 in New York and for crude petroleum in 1859 in Pennsylvania. Oil-well drilling spread rapidly over Pennsylvania, West Virginia, Ohio, New York, and Ontario after 1859. Large-scale commercial production and marketing of natural gas began in 1878 when the country's first big gas well was completed in Pennsylvania; and they spread from that State to Ohio and West Virginia in 1884, Illinois in 1885, and Indiana in 1886.

These areas that saw the first commercial production of oil and gas were also to witness the birth and growth of petroleum geology. The early development of petroleum geology was modest and at times irregular, but full stature was attained by it late in the nineteenth century through the contributions of Edward Orton of Ohio and I. C. White of West Virginia. The potentialities of this mature youth were not fully appreciated until 1915 by its parent, the petroleum industry. At that time it was put to work, with all its energy, to guide exploration for new oil and gas fields. The incentive for this full utilization of petroleum geology was the growing demand, early in the twentieth century, of automobile owners, for gasoline to run the mounting number of automobiles.

In the history of our Nation and in the lives of our people our petroleum and natural gas have played a leading role. They have contributed to our welfare and industrial progress; they carried our armed forces to victory in World Wars I and II; and they provide assurance for our country's future welfare and security.

The Geological Survey was founded in 1879, 20 years after the drilling of the Drake well. It directed its first attention to the oil and gas resources of the United States in the late eighties and early nineties when it published reports on petroleum and natural gas in Ohio and Indiana. A continued and intensive program of oil and gas work was begun by the Survey about 1900, and an administrative mineral fuels unit was established in 1908. M. R. Campbell, the first Chief of the unit, was followed successively by David White, K. C. Heald, W. T. Thom, Jr., the present speaker, and C. H. Dane.

Campbell, like other pioneer oil geologists, Orton, J. S Newberry, E. B. Andrews, and John A. Bownocker, was an Ohioan. He received his geologic training under Orton in Columbus. Other Ohioans, besides Campbell, to join the U. S. Geological Survey and become leaders include:

C. Willard Hayes, who was Chief Geologist from 1902 to 1911.

W. C. Mendenhall who was in charge of ground water investigations of the United States, 1907–10; Chief of the land classification board, 1910–20; Chief Geologist, 1922–31; and Director. 1931–43.

Another Ohioan in Washington is Miss Pearl F. Zeigen, who has been my faithful secretary for the past 20 years.

The first report on the geology of petroleum to be published by the U. S. Geological Survey was by Edward Orton. This report on "The Trenton limestone as a source of petroleum and inflammable gas in Ohio and Indiana" was published in 1889 in the Survey's Eighth Annual Report. It followed by several years the direction of Orton's interest to the subject of petroleum geology and was one of many reports that he published on the subject. One of these pioneer papers printed in 1890 was the first one on petroleum geology to be published by the Geological Society of America. At that time Orton and Israel C. White, State Geologist of West Virginia were the foremost authorities on the subject. In the discussion of Orton's paper in the Bulletin of the Geological Society of America, W J McGee, of the United States Geological Survey, paid the following tribute to the work of these two men:

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[1] Published with the permission of the Director of the U. S. Geological Survey. This paper was presented as one of the Bownocker Lectures at The Ohio State University on January 20, 1948, and as one of the Grant Memorial Lectures at Northwestern University on March 11, 1948.

"But within the past three years the laws governing the origin, distribution, and pressure of rock gas have become as well known as are the laws governing artesian water supply; so that today the geologist prognosticates rock gas nearly if not quite as definitely and certainly as he prognosticates artesian water; and it is not only just to our associates and to American science to say that this great advance in geologic science was due almost wholly to two of our fellows—to Professor Orton, the author of the communication before us, and to professor White who has already spoken upon it. To these men we are indebted for this unparalleled stride in American geology."

Orton was the first to publish consistent conclusions on the origin and accumulation of petroleum and on the relation of artesian pressure to oil and gas pressures. Also he brought out the fact that the porosity of the Trenton is dependent on the extent of dolomitization, and that this factor largely governs location of the productive areas scattered over the great Cincinnati arch. He also introduced in the United States in 1888 and 1889 the use of structure contours for showing oil field structure. By means of the contours and shading between them he showed the topography of the Trenton limestone in western Ohio and eastern Indiana.

White published in 1885 his epochal statement on the anticlinal theory of oil accumulation and on his practical application of it. Other geologists including Hunt (1861), Rogers (1860), Logan (1844), and Andrews (1861), had observed the association of oil accumulations with anticlinal axes. Their opinions appear to have little influence on oil exploration and they were strongly opposed by J. P. Lesley. So important was White's statement that Orton proclaimed that his applications of the theory mark a new period in our study of the geology of oil and gas.

It was under Hayes' guidance as Chief Geologist of the U. S. Geological Survey that the refinements of detailed stratigraphic and structural studies were first to be applied in a large way, beginning about 1900. Mining engineers and geologists had, of course, applied similar methods to small areas before Hayes introduced them into the National Survey. It remained for him, however, to show that detailed structures could be worked out over large areas without an inordinate expenditure of time and money. It was his success in the locating of oil pools that led to his being called later to assume charge of the geological work of the Mexican Eagle Oil Co. in Mexico.

About 1900 the U. S. Geological Survey began the examination of a number of oil-producing areas in the Appalachian States, particularly Ohio and Pennsylvania, and structure contours were an essential feature. These reports did much to popularize the use of such contours.

The first of these reports to show the detailed structure of an oil-producing sand by means of structure contours was Bulletin 198, "The Berea grit oil sand in the Cadiz quadrangle, Ohio," by W. T. Griswold. This quadrangle was surveyed in 1901 by Griswold, who introduced the plane table for geologic mapping in connection with his mapping of the topography of the quadrangle.

Industry's adoption of geology as a guide to the study of oil and gas deposits in 1915 was based on the reports of the few geologists in company employment and on reports of the U. S. Geological Survey and various State Surveys, notably the Oklahoma and Kansas Surveys and the California State Mining Bureau.

These reports demonstrated clearly, for many areas, the relation of oil and gas accumulations to anticlinal structure. As a consequence, the early part of the present century witnessed the beginning of a vigorous search for anticlines as drilling sites for oil and gas wells. Also, the Geological Survey made a notable contribution to the development of the oil and gas industries through the training of petroleum geologists who subsequently resigned from the Survey between 1908 and 1925 to join large geologic staffs that were being organized by the oil companies. These geologists, who were thus Geological Survey graduates, became a significant proportion of the leaders in a world-wide search for petroleum.

The oil work of the Geological Survey was greatly accelerated during World War I and again in World War II. In World War I the Geological Survey responded to the imperative need for increasing to the utmost the petroleum supply of the United States, and it largely concentrated its investigations of oil fields in the most promising undeveloped territory, such as Wyoming, and the mid-Continent-Texas region, and especially in the Osage Reservation in Oklahoma. The Osage Reservation demanded particular attention at the time for the following reasons: (1) it contained a great acreage of unleased oil lands; (2) the productivity of the developed areas was high and well sustained; (3) anticlines and domes are numerous in the greater part of the area and the developments and tests indicated that most of the structurally favorable folds would yield oil; and (4) the Office of Indian Affairs, which administers the lands held in common by the Osage Indians, was then offering leases of hundreds of quarter sections to openly competitive bidders on advertised dates. Altogether some 45 geologists and instrument men took part in this investigation of the Osage Reservation under the supervision of K. C. Heald. The long list of their names is most impressive for it is a roster of present-day leaders, of whom two, W. B. Emery and E. M. Spieker, now live in Ohio. To these geologists and instrument men, David White, Chief Geologist, paid the following tribute:

"The field work, which included plane-table mapping with telescopic alidade under many hardships in addition to those of the severe winter (of 1917–18) was carried forward with splendid team work and with gallant and indefatigable emulation. In recording his admiration for the esprit and high standard of this War Work done by geologists in professional civil service, the writer believes he expresses the appreciation not only of the Geological Survey but of the operators as well."

The World War II period of acceleration of oil and gas work began in 1943 and is still in progress; it exceeds in magnitude any oil and gas work heretofore undertaken by the Survey. The number of geologists employed in the Fuels Section in recent years has reached a maximum of about 100 and the number of clerks, draftsmen, and other employees has reached a top figure of about 30.

The purposes of the Survey's present oil and gas work do not differ from those that have guided similar work by the Geological Survey at all other times during the past 50 years. On the other hand, as the methods and techniques of industry have changed during the past 50 years, the nature of the Survey's work has changed.

The mapping of local structural features has been stressed less and less by the Geological Survey and greater emphasis has been placed on regional geologic problems, although some effort is necessarily being directed specifically to the acquisition of information essential for the administration of laws relating to the leasing of public lands for oil and gas development.

The type of work that is being emphasized in recent years is regional geology involving both subsurface and surface stratigraphy in large areas, such as basins or similar geologic provinces. Studies are being devoted primarily to the accumulation of data for the preparation of maps and stratigraphic sections showing such features as the thickness and change in facies of oil-producing formations, the margins of producing or possible producing zones, and the relations and extent of lenticular sands. These studies have as their objective the delimitation of broad areas that are favorable for exploration. The determination of local structural features, whether by surface, subsurface, or geophysical methods, is not being stressed.

In the formulation and prosecution of the present program of regional stratigraphy and structure the counsel of petroleum geologists and also State Geologists was sought. Many hundreds of petroleum geologists, the officials of numerous educational institutions, and about 24 State Geologists have provided suggestions concerning projects, methods of procedure, and other forms of cooperation and assistance. Also, the program of geologic work is being carried out with the active collaboration of the oil and gas industries, many universities, and the State Geological Surveys. This collaboration assures effective prosecution, without duplication of effort, of types of projects that yield useful results.

The present program of work has been decentralized. Nearly all the work is being done outside Washington. The field employees reside and prepare their reports at project offices. The employees in the Washington office are engaged in the administration of the program, and in the review and processing of reports for publication.

The maintenance of the project offices in the States has many advantages. The field geologists are thus located in areas conveniently near sources of information and are in close personal contact with company geologists and the officials of State Geological Surveys and universities. These contacts give opportunity for the exchange of ideas and for mutual understanding among those who are interested in common problems.

Project field headquarters are now located at the following places: New Philadelphia, Ohio; Ann Arbor, Michigan; Tallahassee, Florida; Tuscaloosa, Alabama; Tulsa, Oklahoma; Lawrence, Kansas; Denver, Colorado; Laramie, Wyoming; Billings, Montana; Albuquerque, New Mexico; and Claremont, California.

Other headquarters that have been used at different times in the past four years are Nashville, Tennessee; Oxford, Mississippi; Morgantown, West Virginia; Austin and Fort Worth, Texas; Norman, Oklahoma; Corvallis, Oregon; and Los Angeles, California.

The different parts of the United States where work by the Fuels Section has been under way during the past four years, include California, Oregon, the Rocky Mountain region from New Mexico to Montana, many States in the mid-Continent region from Texas to Michigan, the southeastern States from Mississippi to Florida, and the Appalachian region from Tennessee and Virginia to Ohio and New York. These areas cover a considerable proportion of the parts of the country that produce petroleum and natural gas or are favorable for their production.

Basic geologic data obtained by the Geological Survey in the course of its work are being made available promptly, through publications, to those directly concerned with the drilling of wells and the testing of new areas. The oil and gas investigations are so planned that useful and timely results can be published rapidly. The results are embodied in large measure in a series of preliminary maps and charts on which brief explanatory texts are printed.

The Geological Survey has printed 110 such maps and charts in its current series. More than 77,000 copies have been sold. Also, during the past 4 years, numerous articles and reports have been submitted for publication to trade and scientific journals and cooperating agencies.

Some types of the preliminary reports are on display on the walls of this auditorium. A complete display of our maps and charts, placed end to end and pasted together, would make a sheet of paper 500 feet long.

Petroleum geology in the U. S. Geological Survey is largely centered in the Fuels Section of the Geologic Branch. The work of this section is closely coordinated with the fields of other sections of the Geological Survey that deal primarily with paleontology, stratigraphy, chemistry, physics, geophysics, mineralogy, and petrology. In fact, much of the work of these several sections, outside their collaboration with the Fuels Section, is devoted to providing basic information that is utilized by the oil and gas industries in their search for, and development of, our oil and gas resources. Thus, much of the geologic effort of the Geological Survey is related to oil and gas, either directly or indirectly.

In addition to the geologic work of the Fuels Section, some studies that are essential for the administration of the oil and gas bearing public lands are conducted by the Conservation Branch of the Survey. Moreover, intensive studies of the oil and gas resources and possibilities of Alaska have been made since 1903 by Geological Survey geologists. E. M. Spieker has participated in pioneer work in recent years in that frontier area.

The Appalachian project with headquarters at New Philadelphia, Ohio, is typical of many regional projects that were begun in 1943 to assist in the search for much needed oil and gas.

In August 1943, James F. Pepper, the chief of the party, and I made a trip through the Appalachian Basin to see what might be the consensus of geologists of the area as to the type of work that would be most useful to industry. We visited the geological surveys of Ohio, Pennsylvania, and West Virginia, and the geological societies at Charleston, West Virginia, and at Pittsburgh, Pennsylvania.

The decisions reached during this canvas were as follows:

1. Because the project was financed by Federal funds the problems should cover several States and be regional in scope.

2. No regional subsurface studies of a producing sand had ever been made in the Appalachian Basin, nor had extensive surface and subsurface studies been made of a sequence of related beds to determine in so far as possible (a) the facies changes over a broad region, (b) the source areas of the material in the beds, (c) the manner of deposition of the sediments, and (d) the paleogeography of the producing sand and related beds.

The conclusion was reached that an intensive study of a sand following the above outline would be most useful. Before a suitable sand for study could be decided upon several other definite requirements had to be met, namely,

1. The sand must be, or have been, a prolific producer of oil and gas.

2. Many hundreds of well records and locations must be readily available in the files of State organizations and private industry.

3. Since personnel would have to be trained on the job, the correlation problems of at least a part of the area must be at a minimum.

The Berea sand seemed most nearly to fulfill all of the requirements and it was selected, therefore, for intensive study.

All of the personnel of the Appalachian Project arrived by October 1943. The party at that time consisted of nine geologists, a clerk, and a draftsman. Most of the geologists were new to oil and gas geology. One geologist of the group, Gordon Rittenhouse, was a specialist in sedimentary petrography. He was assigned to Morgantown, West Virginia, where the State Geological Survey made available an exceedingly well equipped laboratory for his use.

The project quickly lined up into the following procedures:

1. Several geologists were assigned to the field to copy the many well records and locations required in the study.

2. Other geologists in the New Philadelphia office located the wells on topographic maps, plotted the well records and made a correlation of the Berea sand between wells. The thickness of the Berea sand in each well was spotted in its appropriate location and the thicknesses were drawn together by contours or isopachous lines.

The region in Ohio, Pennsylvania, West Virginia, and Kentucky, in which the Berea sand is present, was divided arbitrarily into six nearly equal areas for convenience in collecting and correlating data and for publication of the data.

The completed preliminary study of the Berea sand consisted of six preliminary maps, two of which have since been revised, a preliminary chart (No. 21) by Wallace deWitt, Jr., and a map showing the distribution of several types of Berea sand by Rittenhouse. A map (No. 5) of an older sand, the second Berea sand of Ohio, was published also.

In the study of sand in a large region, such as the Appalachian Basin, much information is acquired. A great part of the information is suitable for the study of sedimentary deposits. For instance, a side issue was a study of the areal extent and thickness of salt beds in Ohio by Pepper, a study of which, if not purely scientific, will be of use to an industry interested in obtaining salt for chemical or other purposes, to say nothing of the hilarity already induced by the coincidental association of names.

Altogether, as a result of the initial investigation of the Berea sand in Ohio, Pennsylvania, West Virginia, and Kentucky, 22 preliminary maps and articles have been published. These publications, as previously mentioned, are an outgrowth of the vast supply of information now on hand. The papers have included grain size analyses, procedural techniques, and an analysis of the paleogeography of the Greenbrier limestone by Rittenhouse.

As a result of the studies of the Berea sand, the information from all preliminary maps and other sources has been compiled into a manuscript for a professional paper. At present, this report is, in its preliminary writing, about 95 per cent complete.

The present plans of the project include an intensive study of the Clinton sand. The compilation of the preliminary Clinton data is now nearly complete and the material is now ready for study. Other work in the Appalachian Basin will include surface mapping of the Dunkirk formation of Devonian age in New York. This study, it is hoped, will determine the correlations and stratigraphic relations of the Dunkirk and Wiscoy formations from Lake Erie eastward to central New York. The results of this study will aid further in the correct interpretation of the stratigraphic relations of the formations in several quadrangles in central New York which, at the present time, are about three-fourths mapped.

It goes without saying that a project covering such a large region (approximately the size of California or of Great Britain) would be futile and its results entirely negligible if it were not for the willing and general cooperation of state surveys, oil and gas companies, and individual operators. One of the unknown factors at the start of the Appalachian Project was the extent to which all who were interested in oil and gas in the Appalachian Basin would cooperate with the Survey. Time has shown that the cooperation, interest, and generosity of all contributors have been exceeded in no other area in the United States. It must be remembered that the Appalachian Basin has no regional scouting service, and with the exception of an agency in Charleston, West Virginia, (specializing in West Virginia well records), no log service of any kind. The generosity of organizations and individuals is all the more remarkable considering the amount of time which they have given the Survey and the amount of trouble members of the Appalachian Project have imposed upon them in obtaining well records. For example, the Appalachian project, in copying well records at the Ohio Fuel Gas Company, totaled a full year's working time for one person. To the Geological Department of the Ohio Fuel Gas Company and to its parent company, the Columbia system, and other subsidiary groups, the Appalachian Project owes a deep debt of gratitude. In Ohio the Appalachian project owes gratitude to the State Geological Survey and its members, past and present,—particularly to Mr. Wilber Stout, ex-State Geologist, to Mr. R. E. Lamborn, Assistant State Geologist, to Dr. George W. White, recent State Geologist, and to Mr. John H. Melvin, the present State Geologist. These companies and individuals and also the Pure Oil Company of Newark, Ohio, and the independent producers of Marietta, Cambridge, and Canton, Ohio, are only a few of the many in Ohio, Pennsylvania, West Virginia, and Kentucky who have been of great assistance to the project, for without their assistance the record of the Appalachian project would be entirely barren of results.

The United States has for many years produced about three-fifths of the world's petroleum. Continuation of this rapid rate of drawing on our supplies will hasten the approach of the day when the discovery rate of petroleum will decline to the point where our crude petroleum supplies will not meet fully our needs. Adequate future supplies of petroleum products must at all times be assured for the security and welfare of the Nation. Sources of these products are not alone the crude petroleum in this and other countries but also substitute sources which include oil shale, coal, oil-saturated sands, and natural gas. The domestic deposits of these substitutes sources are large, as established by studies of the U. S. Geological Survey, State agencies, and industry, and they are capable of providing ample petroleum products for fully 1,000 years. The Nation must be equipped with fuller and more adequate information than now available concerning the extent, character, and reserves of these substitute sources and concerning processes of large-scale recoveries of petroleum products from them. This is necessary so that they may be utilized promptly when the Nation is required to turn to them to augment domestic and imported supplies of crude petroleum.

A PROPOSED NEW GENUS NAME MARGANANA AND THE ALLOTYPE DESCRIPTION OF PRAIRIANA HIRSUTA DeL.—GYPONINAE

(HOMOPTERA: CICADELLIDAE)

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The genus name *Margana* was used by Walker in 1865 to designate a group of Lepidoptera in "A List of Lepidopterous Insects of the British Museum. 34, 1520." This same name was used by DeLong to designate a genus of Cicadellidae in the Gyponinae in 1942.[1] A new genus name *Marganana* is thus being proposed for the preoccupied name *Margana*. The type of the genus is *Ponana suilla* Ball.

In the same paper, page 77, the species *Prainiana hirsuta* DeLong was described from two male specimens, one collected at Phoenix and the other at Yuma, Arizona. Recently a large series of males and females was collected at Phoenix, Arizona by Mr Robert A. Flock. The female is therefore being described.

The vertex is a little shorter than male, about three fourths as long as the basal width between the eyes. Length of female, 8.5 mm.

The color of the female is yellowish brown. The elytra of the male are usually dark brown; the elytra of the female are unicolorous with the vertex and pronotum.

The posterior margin of the seventh sternite of the female is deeply, broadly excavated either side of the middle and the laterally produced lateral angles. These excavations form a rather narrow produced lobe at the middle which is exceeded in length by the lateral angles. The female allotype is from Phoenix, Arizona, collected by Robert A. Flock.

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[1] A Monographic Study of the North American Species of the Subfamily Gyponinae (Homoptera: Cicadellidae). The Ohio State Univ. Press, 1942.

A METHOD FOR REMOVING TRANSMISSIBLE LYSINS FROM SECONDARY CULTURES OF BACTERIA[1]

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INTRODUCTION

Precursors of transmissible lysins or bacterial viruses may exist for a given bacterium wherever organic matter is found. The writer has been particularly interested in such sources as seed and grain extracts, crop residues, and the sap of living plants (Thomas 5, 6, 7). Since the addition of grain or plant extracts to primary cultures of bacteria, and also in some instances to secondary cultures, starts the transmissible lysis phenomenon, it seems reasonable to assume that the lytic factor might be removed and the original culture reclaimed if suitable methods could be devised for that purpose.

In a number of instances, bacteria have been rendered apparently free of the lysins associated with them. The method used is outlined in this paper.

It was thought advisable in this preliminary investigation to work only with known cultures. This means that the primary culture and source of the lysin in each instance, were known. The species of bacteria used in this investigation were assumed to be primary species. A comparison of the types of growth of a culture of bacteria, with and without a lysin present, in the same kind of liquid medium furnishes valuable information and enables one to judge from the character of growth of an unknown isolate, whether or not a lytic factor is present. So long as a transmissible lytic factor is in intimate contact with a culture, the secondary growth which develops is no longer susceptible to the same lysin, because usually in a secondary growth, the lytic factor continues to develop with the organism indefinitely. The presence of a lysin can be demonstrated by testing the bacteria-free filtrate of a secondary culture against the primary or original organism. These secondary cultures are usually considered to be resistant to lytic action. Such cultures are so saturated with the lysin that the addition of more has no effect. The lysin-organism relationship of secondary cultures has never been satisfactorily explained.

The possibility of removing a transmissible lysin from a bacterium would depend upon the kind of affinity or relationship which exists between the two—whether the combination is fixed or reversible. A host-parasite relationship might be expected to be irreversible and there could not be much hope of bringing about a separation. On the other hand, if the lytic condition is due to an acquired enzyme or nucleoprotein, a separation may be feasible. In any case, it would be necessary to find an adsorbent which would have at least as great, if not greater, affinity for the lytic substance than its homologous bacterium.

Early investigators of nucleic acids discovered that these acids have a remarkable property of removing proteins from solution. The combination of albumin and syntonin with various nucleic acids was studied by Milroy (4). Evidence seems to indicate that the viruses are at least in part protein. Tobacco mosaic virus is thought to be a nucleoprotein. It was therefore decided to determine what effect nucleic acids might have upon the lytic factor bacterium combination of different species of bacteria and to find out if an organism could be rendered again susceptible to lysis by removal of the virus by adsorption on nucleic acid.

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[1] Published with the approval of the Director of the Ohio Agricultural Experiment Station.

METHODS OF INVESTIGATION

Nucleic acids are available commercially from only a few different sources. Preparations from yeast, wheat germs and thymus were obtained. Since these acids are insoluble in water it was necessary to add an alkali to effect solution. For this purpose either sodium hydroxide or sodium bicarbonate solution was used. The preparation from animal tissue was furnished as a sodium salt and was adjusted by the addition of dilute acetic acid pH 6.50 to 7.00.

Other extracts containing nucleic acid from alfalfa, timothy, oats and potato were prepared by digesting 50 grams of the finely ground material with 5 per cent ammonium hydroxide. Extraction was continued for about three hours, with frequent stirring, on a water-bath heated to 70°C. The liquid was then removed by filtering, the ammonia neutralized with hydrochloric acid and the precipitate which formed was collected by centrifuging. The crude extract was redissolved with ammonium hydroxide and reprecipitated twice, then washed to remove ammonium chloride, and finally suspended in 50 milliliters of distilled water. A few drops of sodium hydroxide were added to bring the suspension into solution. These crude extracts were used without further attempts at purification.

A 2 per cent solution of each commercial nucleic acid was prepared. Whatever micro-organisms were present were removed by filtering through a sterile Selas candle. One milliliter of the filtrate was added to 8 milliliters of sterile nutrient broth or distilled water. Then, each tube containing sodium nucleate was inoculated with one drop, approximately 1/20 of a milliliter, of a secondary culture containing a transmissible lysin. After thoro mixing the preparation was allowed to stand at room temperature for periods varying from 1 to 12 hours. The period of contact of the lytic factors with the different cultures varied from 2 weeks to 3 months. This did not seem to be of much importance. If it was at all possible to free some of the organisms of a culture from the lysin the time of previous contact or association was of little significance.

At varying intervals, after a culture had been in contact with a nucleate, dilution plates were poured, using nutrient agar. These plates were incubated for 3 or 4 days at 28°C. Then single colonies were selected and transfers made to tubes of broth. Dilution plates were made also of the original culture which did not contain a lytic substance. Using the type of colony growth found in these plates as a guide, similar colonies were picked from the plates prepared from the secondary culture treated with sodium nucleate. Usually only surface colonies, with regular or entire margins showing a smooth type of growth, were selected. If the primary culture developed a pigment, then only colonies showing the same shade of color were chosen for transfer.

After incubation for 24 hours a comparison of the growth of the new isolates with that of the parent culture furnished a good indication if any had been selected which were lysin-free. Colonies still containing a lysin either failed to make any growth or developed only a slight clouding of the broth. The isolates which grew normally were next tested against the original virus filtrate. If they showed the same susceptibility to lysis as the primary culture, they were assumed to be virus-free. Cultures of isolates which still retained the virus were not susceptible to lysis by the original lytic factor. The presence of a lytic factor in an isolate which shows only limited growth can be demonstrated readily by testing the filtrate of such a culture against the parent culture or against those isolates from which the factor has been removed. This procedure can be used for analyzing a species of bacteria which may be suspected of harboring a virus, thus rendering it virus-free and of learning the nature of the original form from which the secondary strain was derived.

RESULTS

In table I is shown a number of species of bacteria for which transmissible lysins were developed from known sources and from which they have been removed. The criterion of lysin removal is based on the fact that the new isolates, following treatment with a sodium nucleate, regained susceptibility to the original lysin. So long as a lytic factor was in association with a secondary culture it did not show any evidence of lysis.

In nearly all cases, secondary cultures developed from the bacterial species recorded in table I retained their lysins in symbiotic relationship regardless of how many transfers were made in such media as nutrient broth or agar. One exception was *Xanthomonas pruni* which could be rendered lysin-free by merely plating in nutrient agar. This could not be done with any of the other secondary cultures without previous contact with some kind of nucleic acid or plant extract. All of the nucleic acid salts and plant extracts used as lysin adsorbants give Feulgen's reaction. Agar-agar also gives this reaction. Probably there is sufficient adsorbing material in agar-agar to remove the lytic factor from *Xanthomonas pruni.*

TABLE I

NUCLEIC ACIDS AND PLANT EXTRACTS ARE USEFUL AS ADSORBENTS OF TRANSMISSIBLE LYSINS

Organism	Source of lysin	Source of adsorbent	Period of contact with adsorbent	Number of isolates	Number reacting with original lysin
Xanthomonas juglandis	Oat extract	Thymus	9 hrs.	6	2
Xanthomonas stewarti	Oat extract	Wheat germ.	12 hrs.	12	10
Erwinia carotovora	Oat extract	Wheat germ.	3 hrs.	6	1
Corynebacterium sepedonicum	Potato vine	Potato extract	2 hrs	18	10
Corynebacterium michiganense	Oat extract	Wheat germ.	4 hrs	6	4
Xanthomonas pruni	Oat extract	Wheat germ.	3 hrs.	6	6
Escherichia coli	Animal	Wheat germ.	1 hr.	6	5
Escherichia coli	Animal	Wheat germ.	2 hrs.	6	5
Escherichia coli	Animal	Wheat germ	7 hrs.	6	0
Staphylococcus aureus	Human	Wheat germ.	2,hrs.	4	2
Unidentified species AC	Oat extract	Wheat germ.	1½ hrs.	8	7
Unidentified species 1A.	Alfalfa extract	Wheat germ.	3 hrs.	5	5
Unidentified species 1A.	Clover extract	Wheat germ.	3 hrs.	5	5
Unidentified species 1A.	Timothy extract	Wheat germ.	3 hrs.	5	0
Agrobacterium tumefaciens	Oat extract	Thymus	4 hrs.	12	5
Agrobacterium tumefaciens	Oat extract	Timothy	4 hrs.	6	6
Agrobacterium tumefaciens	Oat extract	Alfalfa	4 hrs.	6	6
Agrobacterium tumefaciens	Oat extract	Oat grain	4 hrs.	6	4

There does not seem to be much correlation between the source of lytic factors and the kind of nucleic acid used to remove them. Thymus nucleic acid was effective for the lysins of *Xanthomonas juglandis* and *Agrobacterium tumefaciens,* both of which came from a plant source. Nucleic acid from wheat germs removed lytic factors from *Escherichia coli* and *Staphylococcus aureus*, the lysins being of animal origin in both cases.

The only instance of strict specificity is found with *Corynebacterium sepedonicum.* The lysin for the organism had come from an extract of a dead potato vine which had succumbed to the ring-rot disease. An extract of potato tuber only was found to be of value for adsorbing the lysin of that organism and thus restoring it to its primary form and rendering it again susceptible to lysis by the original lytic factor.

The necessary period of contact of a secondary culture with the nucleic acid varied with the organism, and the optimum time could be determined only by trial platings at stated intervals. Those which yielded best results are recorded for each culture in table I. For *Escherichia coli* a contact period of one or two hours before a sample was removed for plating gave virus-free colonies, but 7 hours were too long. Nucleic acids and plant extracts prevent the growth of some species of bacteria indefinitely while other species start to grow sooner or later. Growth of *Escherichia coli*, before the 7-hour period of contact would account for the multiplication of the virus and also for the fact that no colonies could be obtained susceptible to lysis at that time.

Nucleic acids from four different sources were effective for adsorbing lysin from a secondary culture of *Agrobacterium tumefaciens*. When a secondary culture of this organism, without previous contact with a nucleic acid, was plated on nutrient agar, no colonies were ever found free of the lytic factor.

Cultures of virus-free bacteria killed by heating at 60°C. for 30 minutes were used instead of nucleic acid in order to determine if the lytic particles would be fixed on the dead bacteria. No organisms from which the lytic factor had been separated were ever obtained by platings from such preparations.

The removal of a lytic factor from a culture, thus restoring it to susceptibility to lysis and to normal growth in ordinary media, does not furnish assurance that the reclaimed culture is identical with the original in all respects. In order to gain further information in this connection, plant inoculation was tried. Tomato plants were inoculated from cultures of *Agrobacterium tumefaciens* with and without a lysin present and also with isolates from which the lytic factor had been removed and which had again become susceptible to lysis.

The presence of a lytic factor developed from oat grain extract in a culture of *Agr. tumefaciens* prevented that organism from developing galls when inoculated into tomato plants. After the lysin had been removed by treatment with timothy extract, the culture was again rendered susceptible to lysis and also regained capacity to produce galls.

DISCUSSION

Many species of bacteria, particularly primary forms, acquire lytic factors readily when they come into contact with the juices of higher plants, seed extracts and plant residues. The presence of a lytic factor in a culture somehow changes the metabolic activity of the organism. Evidence of this is indicated by failure of the secondary culture to grow in the same medium as the primary, by the need for vitamin or amino acid amendments and by change in color.

With a more definite understanding of the sources of lytic factors it is proper to raise the question regarding any recognized species of bacteria, whether it is a primary or secondary form. This consideration may have a definite bearing upon our viewpoint of classification and nomenclature in the future. If we can take a primary organism and develop a number of different variants or strains with the aid of plant or seed extracts our conception of what constitutes a species or a strain will be brought more definitely into focus.

Secondary forms of bacteria may be anticipated in fermentation processes where the substrate is seeds, grains or plant material which have not been thoroly sterilized by heat.

The fact that nucleic acids are effective in removing transmissible lytic factors from bacteria, thus permitting the organisms to develop as they did before a lysin was added to a culture, suggests that a class of enzymes known as nucleases may enter into lysin formation. A nucleic acid might be expected to have greater affinity for a nuclease than for other enzymes or proteins.

Very little is known regarding the nucleases, particularly their action on living substrates. Ribonuclease was prepared from commercial pancreatin by Dubos and Thompson (1). Kunitz (3), using different methods, isolated the same enzyme in crystalline form from the same source. This particular nuclease readily attacks the sodium salt of yeast nucleic acid. Greenstein (2) reports that thymonucleodepolymerase occurs not only in animal but also in plant tissues. Extracts of the embryos of corn, wheat, pumpkin, sunflower and lima bean exert a strong depolymerizing effect upon sodium thymonucleate. Apparently the distinction between plant and animal nucleic acids is rapidly disappearing. This fact is also evident in the general lack of specificity among nucleic acids in separating lytic factors from bacteria.

SUMMARY

Transmissible lytic factors can be removed from bacteria and the organisms restored to their original form.

Organisms which have been rendered lysin-free again become susceptible to lysis by the original lytic factor. In the case of *Agrobacterium tumefaciens*, the recovery of the capacity to induce gall formation in tomato was demonstrated following treatment with timothy extract.

The method of procedure outlined in this study can be applied to a culture which may be suspected of having a transmissible lysin associated with it. The parent primary culture frequently can be recovered.

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A SYNOPSIS OF THE GENUS IOWANUS IN NORTH AMERICA INCLUDING MEXICO

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While discussing the Phlepsids of Mexico and Central America in 1918, Ball[1] erected several new subgenera, one of which he named *Iowanus*. He cited as the genotype ***Phlepsius* (*Iowanus*) *handlirschi*** Ball, a Mexican species occurring in the state of Guerrero. Other species placed in this subgenus by Ball are ***majestus*** O. & B., ***elongatus*** Ball, ***hebraeus*** Ball and ***spatulatus*** V. D.

In characterizing this genus Ball states, "Resembling ***Phlepsius*** but with head much narrower than pronotum, vertex narrow, disc flat, front long and narrow, but slightly widening above. Pronotum large, pushed forward between the eyes, the lateral margins long and strongly oblique. Elytra very long and narrow over one-third their length beyond clavus; central apical cell long, curved, narrow at base. Surface of elytra regularly inscribed with vermiculate lines."

In 1939 the senior author[2] described four species of this genus which are closely related to ***majestus*** under *Texananus*. A study of this material in comparison with *Texananus* indicates that *Iowanus* should be given generic rank. Ten previously described species are being placed in the genus and two new species are being described and placed in the genus in this synopsis.

KEY TO SPECIES

1 Body narrow, not widened at middle; female segment strongly produced, extending almost to apex of pygofer; sides concavely rounded to narrow sharp pointed apex; male unknown. (Species known only from Mexico) . . . . **elongatus**

1' Body broader, definitely broadened at about half its length; female segment either truncate or slightly produced, not nearly as long as pygofer 2

2(1') Vertex with a definite black or dark brown transverse band, usually interrupted at middle, between anterior margins of eyes 3

2' Vertex with brownish mottling forming an irregular band between anterior margins of eyes 12

3(2) Apical half of vertex (portion anterior to black band) white, unmarked; female segment shallowly emarginate either side of a pair of short broad separated median teeth. (Known only from Mexico) . . . . **apicalis**

3' Apical half of vertex same color as basal portion, usually with a pair of small approximate spots 4

4(3') Vertex bluntly produced, almost half as long at middle as basal width between eyes; female segment roundedly produced from lateral margins to form a broad bifid apical tooth which occupies the median fifth of the posterior margin; male pygofer without caudal spines . . . . **sabinus**

4' Vertex more broadened, rounded at apex, scarcely angled; female segment almost truncate, not forming a produced median tooth; male pygofer with caudal spines . . . 5

5(4') Color rather dark brown; female segment slightly produced at middle with a median rather broad, shallow notch; male aedeagus composed of a single process which is long and slender . . . . **hebraeus**

5' Color more chestnut brown; female segment with a deep or narrow median incision or both; male aedeagus composed of an upper and a lower portion 6

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[1] Ball, E. D. Annals Ent. Soc. Amer., 9: 381–389, 1918.

[2] DeLong, D. M. Ohio Jour. Sci., 39: 235–238, 1939.

6(5') Ventral portion of aedeagus cleft for more than half of the apical part forming a pair of long slender processes which are lyre shaped in ventral view.............. **lyratus**

6' Ventral portion of aedeagus not cleft or cleft for only a short distance of apical portion..7

7(6') Male styles slender at apical half and tapered to a pointed apex........... **handlirschi**

7' Male styles broader, blunt at apex, aedeagus notched or cleft at apex................8

8(7') Apex of each apical fork of ventral portion of aedeagus bifid................ **dicentrus**

8' Apex of each apical fork of ventral portion of aedeagus pointed not bifid............9

9(8') Ventral aedeagus portion sharply bent ventrally and produced for more than one-third its length at apex .... **borrori**

9' Ventral portion of the aedeagus with the apical portion not sharply bent ventrally, or with bent portion very short..10

10(9') Apical pygofer lobe broadly rounded, as broad as long, constricted at base; dorso-anterior lobe of dorsal portion of aedeagus broadened apically, constricted at base, **bullatus**

10' Apical pygofer lobe elongate or short, not constricted at base; dorso-anterior lobe of dorsal portion of aedeagus narrowed at apex, not constricted basally. 11

11(10') Apical pygofer lobe appearing short in lateral view, bent inwardly, not constricted basally; apical branches of ventral aedeagus slender, elongate, in lateral view appearing bent twice.. **caducus**

11' Apical pygofer lobe elongate, ovate; apical branches of ventral aedeagus short, thick and curved ventrally.. **majestus**

12(2') Male plates elongate, sloping on outer margins to bluntly pointed apices. ... **spatulus**

12' Male plates longer, more narrow, the apical half narrow and tapered to slender, acutely pointed apices; pygofer longer.............. **ultratus**

Iowanus elongatus (Ball)

Phlepsius (*Iowanus*) *elongatus* Ball, Annals Ent. Soc. Amer. 11: 382, 1918.

Resembling *majestus* but narrower with a long pointed female segment. Length 10 mm.

Vertex angled, about one-third longer at middle than next the eyes, about one-half wider than long. The transverse band covers almost the anterior third of the vertex leaving a pale anterior margin and a median line. Pronotum with three rather distinct dark brown spots near anterior margin behind each eye.

The female last ventral segment tapering from the lateral angles to a long pointed apex which extends almost to the apex of the pygofers.

This species is known from the female holotype specimen only which was collected in Guerrero, Mexico.

Iowanus majestus (Osborn and Ball)

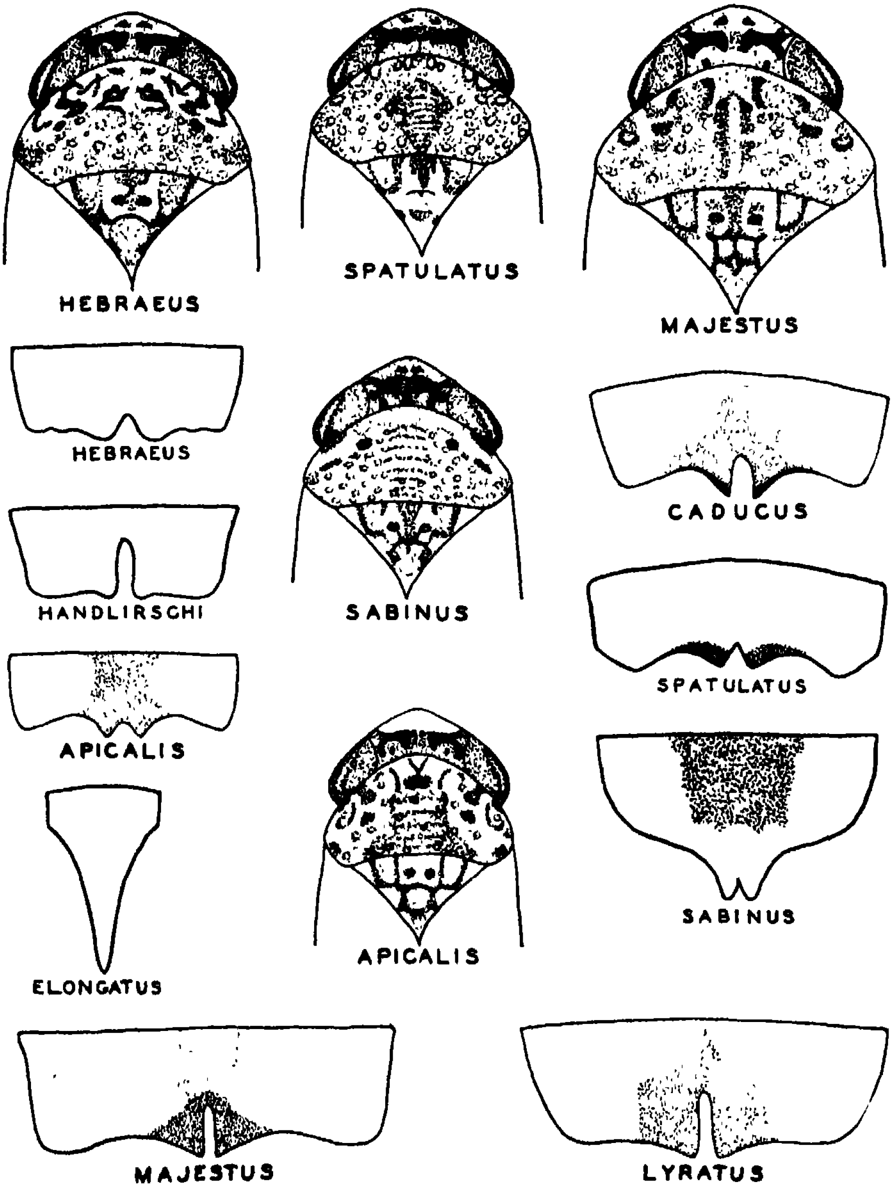
Phlepsius majestus Osborn and Ball. Proc. Ia. Acad. Sci. 4 : 229, 1897.

A large brownish species, resembling a member of the *Gyponinae* in general appearance. Length 9 to 10 mm.

The vertex is bluntly angled, about one-third longer on the middle than next the eyes, margin blunt. Vertex with a conspicuous, irregular, transverse fuscous band on the middle and usually two fuscous spots before it and above apex. Anterior portion of pronotum with dark vermiculate markings. Elytra heavily inscribed with chestnut brown pigment.

The female last ventral segment is three times as broad as long, the lateral angles broadly rounded. A narrow median incision half way to the base forms a rounded tooth on either side. The margin is broadly, shallowly emarginate either side between these and the lateral angles. Male plates rather long and narrow, apices broad, blunt and rounded. Aedeagus composed of a long curved, ventral process which is bifid at apex and a dorsal process which has a long, curved, tapered ventral portion and a shorter, broader dorsal portion, narrowed to a slender, apical finger process. Pygofer concavely rounded, dorsally and ventrally, and produced into a round pointed apex.

This species was described from specimens taken in Philadelphia, Pennsylvania, and has since been recorded for several of the eastern states. The types have been examined but specimens for all of the localities for which recorded have not been checked.



Heads and female genitalia of species of *Iowanus* as labeled

Iowanus caducus (DeLong)

Texacanus caducus DeLong, Ohio Jour. Sci. 39 : 238, 1939.

Resembling *majestus* in form and coloration but with the apical lobe of the pygofer short, blunt, and not indented dorsally or ventrally at the base. Length male 8 mm.; female 9–9.5 mm.

The vertex is bluntly produced, more than half as long at middle as basal width between the eyes. The interrupted band between the eyes is interrupted at middle and enlarged at either end.

The female last ventral segment is scarcely concave between the lateral angles and a slightly produced blunt tooth either side of a rather narrow U-shaped notch reaching one-third the distance to the base. The male plates are long, tapered to rather narrow, rounded apices which exceed the pygofers in length. The pygofers with very short rounded caudal lobes which are not constricted or notched at base. The ventral portion of the aedeagus is long, apical fourth bent abruptly ventrally and cleft, forming two apical processes which are more slender than basal aedeagus body and are separated. The dorsal portion with a ventral, long, curved, slender process from the base of which arises a short, broader dorsal process.

This species is known to occur in Oklahoma, Tennessee and Illinois.

Iowanus borrori (DeLong)

Texananus borrori DeLong, Ohio Jour. Sci. 39 : 237, 1939.

Resembling *majestus* in form and coloration but different due to a bent terminal process of the aedeagus which is more than one-third as long as the basal portion and with a longer terminal lobe of the pygofer. Length 9.5 mm.

The vertex is quite broad and blunt, almost twice as wide between eyes at base as the median length. The dark trasnverse band between eyes is interrupted at the middle.

The female last ventral segment with prominent rounded lateral angles between which the posterior margin is concavely rounded either side of a rather long, sharp, pointed tooth which is produced on each side of a U-shaped notch which extends half way to the base of the segment. The male plates are long and slender, about as long as the pygofers which bear a long rather broad caudal lobe. The ventral portion of the aedeagus is short and robust. The apical third is bent abruptly ventrally, is cleft and forms two long apical widely separated spines. The dorsal portion consists of a long slender, curved ventral process from which arises an elongate, broader dorsal process at the base.

This species is known to occur in Ohio, Illinois and Minnesota.

Iowanus bullatus (DeLong)

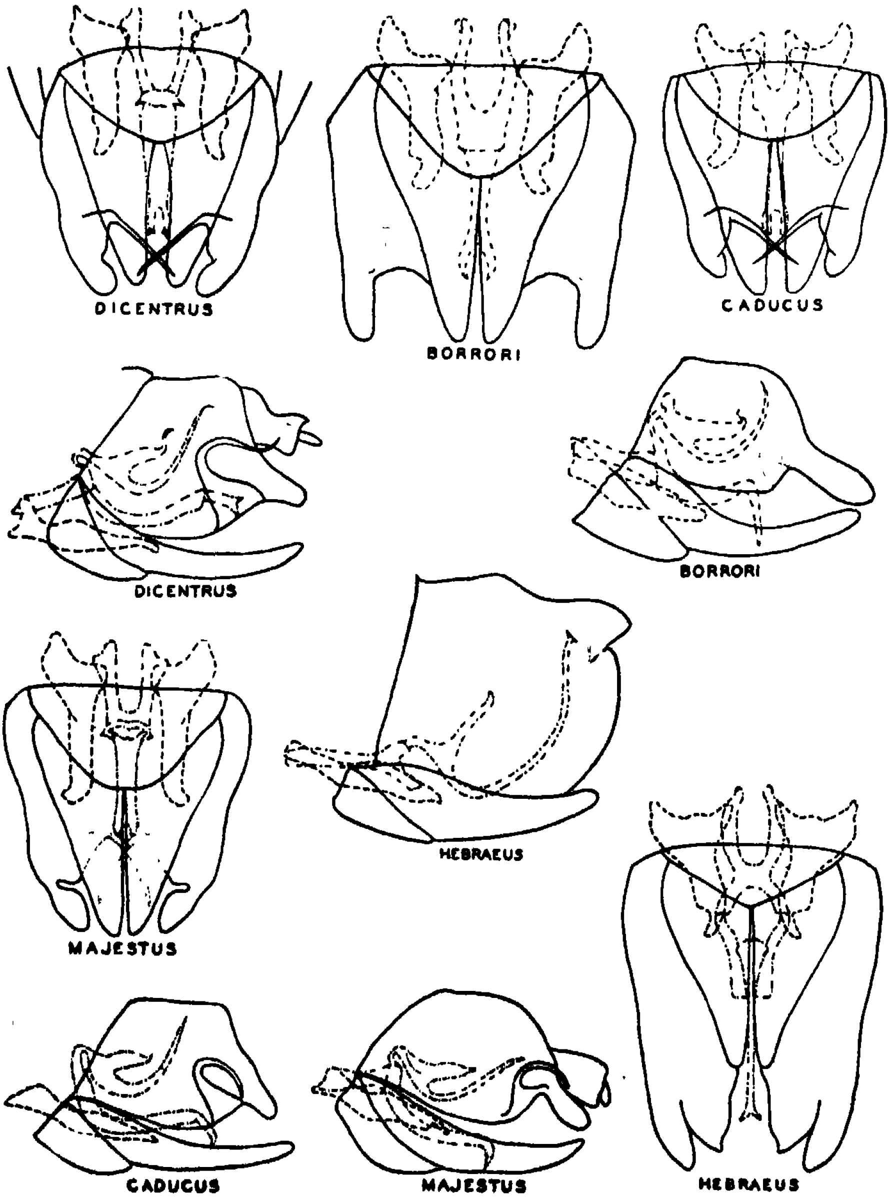
Texananus bullatus DeLong, Ohio Jour. Sci., 39 : 237, 1939.

Resembling *majestus* in form and coloration but distinguished from it by the broader, shorter, convexly rounded male plates and with a broadened basal lobe of aedeagus. Length male 9 mm.; female 10 mm.

Vertex broad, bluntly produced, length at middle more than half the basal width between the eyes. The vertex is marked with a pair of dark points above the apex and a broad straight interrupted dark band between the eyes.

The female last ventral segment is rather deeply broadly emarginate either side of a pair of approximate produced median teeth separated by a deep narrow incision extending half way to the base. The male plates are shorter than the pygofer and almost half as broad as long. The ventral portion of the aedeagus is cleft for a short distance at apex, forming a pair of blunt teeth which are slightly curved ventrally. The dorsal portion of the aedeagus with a long slender process curving caudally then dorsally from which arises a dorsal process at base which is rather broad, forming a rounded lobe. The caudal process of the pygofer is short and broad and broadly rounded.

This species is known from New Mexico only.



Ventral and lateral views of male genitalia of species of *Iowanus* in situ as labeled.

Iowanus dicentrus (DeLong)

Texananus dicentrus DeLong, Ohio Jour. Sci. 39 : 236, 1939.

In form, general appearance and coloration this species resembles *majestus*. Length male 8.5 mm.

Vertex bluntly angled, about three-fifths as long at middle as width between the eyes. The vertex is marked with a pair of brown spots just above apex. There is a transverse band between eyes interrupted at middle and forming a right triangular spot on either side, with the base of triangle along the median line.

The male plates are long, narrowed to bluntly rounded apices. The pygofers are shorter than the plates, the caudal lobe is elongate and narrow. The ventral portion of the aedeagus is forked for about one-fourth of its length at apex and each branch is conspicuously bifid at the apex, bearing a prominent dorsal and a ventral tooth. The dorsal portion of the aedeagus is composed of a long slender process which curves caudally then dorsally almost to the dorsal wall of the pygofer and a shorter dorsal process arising at the base and tapered to a blunt apex.

This species is known only by the type collected in Illinois. The aedeagus of the male is distinct.

Iowanus lyratus n. sp.

Resembling *majestus* in form and coloration but with male genitalia distinctive. Length 9–11 mm.

Vertex broad, scarcely angled, almost parallel margined, not quite twice as wide between eyes at base as median length.

Color of vertex pale, a pair of oblique pale brownish lines extending from beneath the ocelli across margin of vertex and terminating in a pair of proximal spots just above margin at apex. A broad black transverse band just back of ocelli interrupted at middle by a brownish longitudinal line. A pair of brownish dashes on base nearer each eye than middle. Pronotum with darker markings on anterior half. Elytra with ramose pigment lines and a few darker spots.

Female last ventral segment with posterior margin slightly emarginate between humeral angles and median produced portion which is narrowly incised nearly half way to the base. This incision forms a pair of approximate slightly produced, pointed teeth. The median third of segment embrowned. Male plates rather broad and short, bluntly pointed at apex. Styles rather broad at base, narrowed on apical two-thirds. Aedeagus with a ventral process which is long, slender and bifid for more than two-thirds its length; its two arms forming a lyre-shaped structure. The dorsal portion bears a basal process which is rather thick and shorter. The ventro-apical process is longer, slender, curved apically and dorsally.

Holotype male, Atlanta, Ga., September 14, 1939; allotype female same, August 27, 1939, and male paratype same locality, September 2, 1939; all collected by P. W. Fattig.

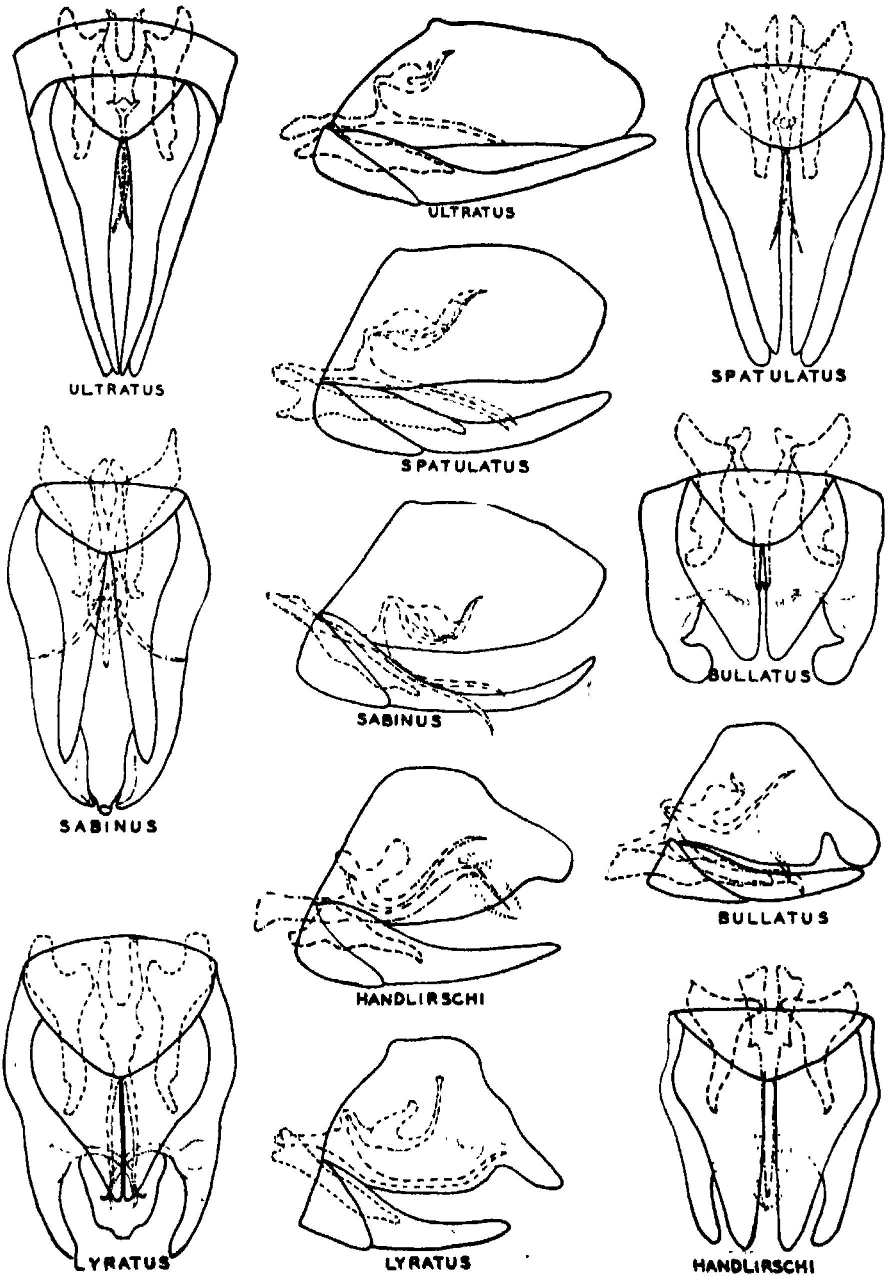
Iowanus handlirschi (Ball)

Phlepsius handlirschi Ball, Annals Ent. Soc. Amer. 11: 383, 1918.

Resembling *majestus* in form and coloration, but differing by having a different aedeagus, shorter blunter apical lobes on the pygofers and styles that are short, narrowed and sharply pointed at the apex. Length 9–10 mm.

Vertex blunt, transverse. The transverse dark band between the eyes is widened on the disc and interrupted in the middle. A pair of proximal spots are just above apex. Pronotum with coarse brown irrorations.

The female last ventral segment is almost truncate on posterior margin with a narrow U-shaped notch extending more than half way to the base. Male plates rather long, narrowed to bluntly pointed apices. Styles short, broad at base, rapidly narrowed at about half their length to form on the inner margin narrow, produced, sharply pointed apices. The aedeagus with a ventral and a dorsal process. The ventral portion is long, slender, curved dorsally, the



Ventral and lateral views of male genitalia of species of *Iowanus* in situ as labeled.

apical fourth bent ventrally and very narrow. The dorsal portion with a pair of dorsal, basal lobes from which a long, slender, tapering process extends ventrally then curves caudally and extends caudo-dorsally, and shorter than ventral portion. The apical lobes of pygofer short and broad, not constricted at base.

This species is known from Mexico only. It was originally described from Mexican material from Guerrero and has since been collected in other localities. The types have been examined and the illustrations made from Mexican material compared with the types.

Iowanus apicalis n. sp.

Resembling *handlirschi* in form and general appearance but with anterior half of vertex ivory white unmarked and with female genital segment more produced like *sabinus*. Length, female, 8 mm.

Vertex broad, bluntly angled, about one-half wider between eyes at base than median length.

Color pale with ramose pigment lines and dark spots or marks. Vertex with a broad black bar between the anterior margins of eyes broken at middle. The ends next the eyes narrower and split into divergent portions, one extending to ocellus and one directed posteriorly. Portion of vertex anterior to transverse bar, ivory white. Pronotum rather evenly mottled with dark brown. Scutellum with a few pale spots, elytra rather heavily marked with dark brown ramose pigment lines and spots.

Female last ventral segment almost truncate to median fifth which is produced and broadly shallowly notched at apex forming a pair of short pointed apical teeth.

Holotype female and paratype female collected at Mexcala, Gro., October 22, 1941 (K. 247) by Good and DeLong A female specimen collected by Dr. Dampf at Tierra Blanca, Veracruz, July 29, 1932 (MF 2655) is also considered to belong to this species.

Iowanus sabinus (Sanders & DeLong)

Phlepsius sabinus Sanders and DeLong, Penna. Dept. Agri. Bur. Plant Ind. Bull. 3: 15, 1920.

Resembling *spatulus* in general form but more heavily marked with black and brown and with distinct genitalia. Length 6.5–7 mm.

Vertex bluntly, broadly angled, white anteriorly with two dark triangular spots just above apex. The transverse band between eyes is broad, irregular, extending to pronotum at middle and is black in color. The pronotum is pale, variously mottled with brown.

The female last ventral segment with posterior margin almost truncate to a median broad brown-tipped produced bifid tooth which is nearly one-third the length of the segment. Male plates long, rather narrow, bluntly pointed at apex. Styles tapered to form narrow apical half. Aedeagus with a long narrow bifid ventral portion and a dorsal portion which consists of three approximate processes. The ventral and median processes are long, narrow and curved. The dorsal process is broadened and shorter and lies within the concavity formed by the other processes.

Allotype male, Globe, Arizona, June 13, 1935, collected by F. H. Parker. This species was originally described from Arizona and has not been reported for other states.

Iowanus spatulatus (Van Duzee)

Phlepsius spatulatus Van Duzee, Trans. Amer. Ent. Soc. 19: 78, 1892.

This species is variously marked but without the definite black transverse bar between the eyes. Length 7–7.5 mm.

Vertex broad, bluntly produced, scarcely angled, more than one and one-half times as wide between eyes at base as median length.

Color pale, white to buff with dark brown markings. Vertex with a pair of approximate brown spots just above margin of vertex. An indefinite brownish transverse band between the anterior margins of the eyes. Pronotum mottled with brown. Elytra pale with brown ramose pigment lines and spots.

Female last ventral segment with a distinct notch at middle of the posterior margin. This forms a blunt produced tooth each side of notch, between which and the humeral angle on each side the posterior margin is shallowly excavated. Male plates long, gradually tapered to acute apices. Styles broad at base, narrowed at about half their length and produced as narrow, almost parallel margined apices. The aedeagus has a pair of long slender ventral processes and a dorsal process composed of two parts—a ventral curved process and a shorter dorsal process.

This is a common and widely distributed species abundant in the herbaceous habitats in the southwestern U. S.

Iowanus ultratus (DeLong)

Texananus ultratus DeLong, Bull. Brook. Ent. Soc. 38: 126, 1943.

Resembling *spatulatus* in general form and appearance but with vertex more broadly rounded. The male plates are extremely long and narrow. Length, male, 7–8 mm.

The vertex is broadly and very bluntly angled, almost twice as wide between the eyes at base as median length. In color the vertex is pale yellow with the irregular brown irrorations forming a broken transverse band between the eyes. The pronotum is rather uniformly irrorate with brown.

The male plates are distinctly narrowed at one-third the distance from base, and produced as long narrow apical processes with pointed tips. Plates more than twice as long as combined basal width. The styles are long and narrow with blunt apices. The ventral portion of aedeagus with a pair of long slender apical processes which extend about one-half the length of the plates The dorsal portion shorter with a ventral elongate process and a dorsal broader and shorter process.

This species is known from Arizona and Arkansas only.

Iowanus hebraeus (Ball)

Phlepsius hebraeus Ball, Annals Ent. Soc. Amer. 11: 383, 1918.

A large, rather distinctly marked species resembling *majestus* in general appearance. Length 8.5–9 mm.

Vertex about twice as wide as long, a little longer on middle than next the eyes. Vertex with the pair of small spots above apex and the dark transverse band interrupted at middle. Pronotum with several dark spots along anterior margin.

The female last ventral segment with a posterior margin which is slightly produced either side of a short broad median notch. Male styles narrow, decidedly shorter than pygofers, gradually tapered to bluntly pointed apices. Styles short, gradually narrowed to form short apical finger-like apices. Aedeagus long, slender, slightly bifid at apex. A short narrow process extends dorsally near base.

The male structures are quite different in type from those of the *majestus handlirschi* group..

This species was described from Mexico and has not been found in the United States.

A CHROMOSONE FREQUENCY TEST FOR LINKAGE OF THE RHESUS BLOOD FACTORS

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Two different hypotheses have been proposed to account for the inheritance of the Rhesus blood antigens. Wiener (3) explains their inheritance on the basis of a set of multiple alleles, while Fisher (2) accounts for it on the basis of three closely linked pairs of factors. At least six different genes are required for either explanation, as three different kinds of Rhesus antigen are known, each of which is dominant in its absence, but none of which show dominance to each other. If multiple alleles are responsible for the inheritance, it means that two genes (Rh$^{\circ\prime}$ and Rh$^{\circ\prime\prime}$) each produce two different antigens. Linkage would mean that each gene would produce only one antigen. The genes and their products, both for multiple alleles and for linked genes are shown below, the three antigens being designated as antigen Rh$^{\circ}$, antigen Rh$^{\prime}$, and antigen Rh$^{\prime\prime}$.

Multiple alleles	*Products*	*Linked genes*
Rh–	no antigen	c, d, e
Rh$^{\circ}$	antigen$^{\circ}$	D
Rh$^{\prime}$	antigen$^{\prime}$	C
Rh$^{\prime\prime}$	antigen$^{\prime\prime}$	E
Rh$^{\circ\prime}$	antigens$^{\circ\prime}$	C, D
Rh$^{\circ\prime\prime}$	antigens$^{\circ\prime\prime}$	D, E

Wiener (3) has tested the multiple allelic hypothesis with gene frequency analysis, and his results show close agreement between the expected and the actual frequencies. Fisher's hypothesis cannot be tested by the usual methods of gene frequency analysis. It is possible, however, to test the linkage hypothesis by *chromosome* frequency analysis, if we have data on the frequencies of the Rh types in a population in which mating has occurred at random. Within such populations, non-allelic genes should occur quite independently of each other. Even genes from sets of alleles too closely linked for any crossing over to occur should still show the same ratios of various combinations within chromosomes as expected on random assortment. That is to say, if alleles Aa and Bb are linked, regardless of how closely, and if the gene frequencies are A–.9; a–.1; B–.1; b–.9; we should expect the following chromosome ratios in the population:

A	B	.09
A	b	.81
a	B	.01
a	b	.09

The frequency of a chromosome carrying any combination of genes, then is the product of the frequencies of these genes.

This note is concerned with such a test for linkage of the Rh genes. Data on actual frequencies is based upon a population of 1,000 in New York City, tested by Wiener and Sonn (3). Gene frequencies are radily obtained from such data. For example, the frequency of gene c is the square root of the frequency of persons lacking antigen Rh'. It follows that $C=1-c$. In a similar manner the frequencies of genes D, d, E, and e may be readily ascertained.

C—.466
c —.534

D—.625
d —.375

E—.161
e —.839

The frequencies of the eight combinations of the Rhesus genes within chromosomes are easily computed and are shown below:

p	C	D	E	.047
q	C	D	e	.244
r	C	d	E	.028
s	c	D	E	.054
t	C	d	e	.147
u	c	d	E	.032
v	c	D	e	.280
w	c	d	e	.168

If p, q, r, s, t, u, v, and w represent the chromosome frequencies, the expected chromosome combinations within individuals are $(p+q+r+s+t+u+v+w)^2$. The frequencies of the expected Rh types within the population are as follows:

CDE $=p^2+2pq+2pr+2ps+2pt+2pu+2pv+2pw+2qr+2qs+2qu+2rs+2st+2rv$
CDe $=q^2+2qt+2qv+2qw+2tv$
cDE $=s^2+2su+2sv+2sw+2uv$
CdE $=r^2+2rt+2ru+2rw+2tu$
Dde $=t^2+2tw$
cdE $=u^2+2uw$
cDe $=v^2+2vw$
cde $=w^2$

The calculated and observed frequencies are shown below:

Classes	*Observed*	*Calculated*
CDE	164	181.963
CDe	541	432.216
CdE	0	29.624
cDE	128	72.686
Cde	9	71 001
cdE	3	11.776
cDe	26	172.480
cde	129	28.224
Total	1000	999.970

Extreme deviations of the observed from the expected are readily apparent, and indicate that the genes responsible for the inheritance of the Rh antigens are not linked.

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(2) **Fisher, R. A.** 1947. The Rhesus factor. American Scientist 35: 92–102, 113.
(3) **Wiener, A. S., and E. B. Sonn.** 1946. Annals of the New York Academy of Sciences XLVI: 883–992.

A STUDY OF THE RATE OF GROWTH OF TWO SCLEROTIZED REGIONS WITHIN LARVAE OF FOUR SPECIES OF MOSQUITOES

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The Ohio State University,
Columbus, Ohio

The observations leading to the following study were made independently by the joint authors and arose from two unconnected studies of mosquito larvae in which measurements of the larvae were a part of the routine. Upon discussion and comparison of data it was decided that, in spite of a difference in approach and method, the information should be pooled in order that a more complete study might be presented.

It is the objective of this paper to determine whether the measurements of head capsule width and air siphon length in different instars are so distinctly separated as to allow one to ascertain from these measurements the stadia or number of larval instars present.

MATERIALS AND METHODS

The larvae of *Aedes aegypti* L., *Ae. trivittatus* (Coq.), *Culex apicalis* Adams and *Anopheles quadrimaculatus* Say were measured for head capsule width and, with the exception of *An. quadrimaculatus*, for air siphon length. The larvae of *Ae. aegypti* and *Ae. trivittatus* were killed in K. A. A. D. killing mixture (Peterson, 1943). They were measured under a binocular microscope in which an ocular micrometer was inserted in one of the 15× oculars. In all the first instar larvae examined the objective used was 2× under which the ocular micrometer was calibrated to 0.09 mm per small division. The remaining instars were examined under a 1× objective with the micrometer calibrated to 0.045 mm. The larvae of both species were obtained from reared material, those of *Ae. trivittatus* from the eggs of wild, gravid females and those of *Ae. aegypti* from a culture maintained in the Department of Zoology and Entomology at the Ohio State University.

The larvae of *Culex apicalis* and *Anopheles quadrimaculatus* were killed in a solution containing six parts water, three parts ninety-five percent alcohol and one part formalin. They, too, were measured under a binocular microscope; however, in this case a 10× micrometer ocular was used with the opposite ocular blacked out. An objective of 48 mm focal length was employed in all measurements. The micrometer ocular was calibrated to 0.0216 mm per small division on the scale. The specimens of *C. apicalis* were taken from a field collection of larvae found in a road side permanent pool. Since several previous and succeeding collections from this pool yielded other species of *Culex* only rarely it was considered that all the instars were a satisfactory representation of the single species. The larvae of *An. quadrimaculatus* were taken from a culture maintained in the same laboratory with that of *Ae. aegypti*.

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[1] The authors extend appreciation to Dr. E. L. Green, Dr. Alvah Peterson and Dr. Carl E. Venard, all of the Department of Zoology and Entomology at The Ohio State University, for their helpful suggestions and criticisms during the development of this study and preparation of the manuscript. Appreciation is also extended to the Statistics Laboratory of The Ohio State University for their statistical analysis of the data presented herein.

TABLE I

Aedes aegypti

INSTAR 1

Air Siphon	Head Capsule Width				Total
	202	225	247	270	
180	1	4	0	0	5
202	0	4	1	1	6
225	0	3	2	1	6
247	0	0	1	4	5
270	0	0	5	5	10
Total	1	11	9	11	32

Mean head capsule width: h = 246
Standard deviation of head capsule width: s_h = 20 6
Mean air siphon length: a = 231
Standard deviation of air siphon length: s_a = 33 4
Correlation coefficient between head capsule width and air siphon length: r = 70

INSTAR 2

Air Siphon	Head Capsule Width				Total
	360	405	450	495	
360	7	15	1	0	23
405	3	14	3	1	21
450	0	3	1	1	5
Total	10	32	5	2	49

h = 402
s_h = 28 5
a = 388
s_a = 30 3
r = 36

INSTAR 3

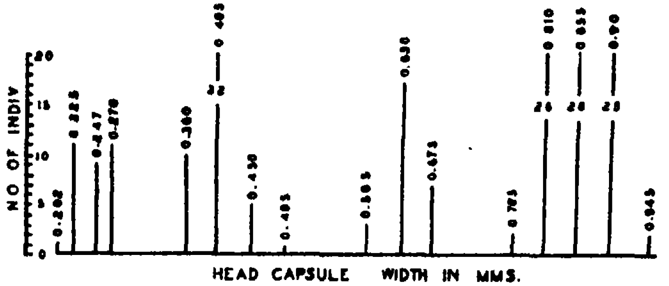
Air Siphon	Head Capsule Width			Total
	585	630	675	
540	0	3	0	3
585	3	9	1	13
630	1	6	6	13
Total	4	18	7	29

h = 635
s_h = 27 8
a = 601
s_a = 30 1
r = 34

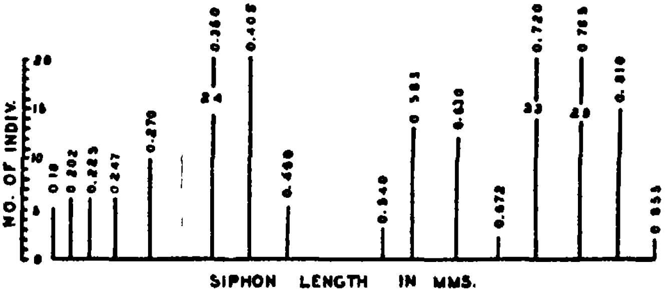
INSTAR 4

Air Siphon	Head Capsule Width					Total
	765	810	855	900	945	
675	0	1	0	1	0	2
720	1	18	11	3	0	33
765	1	7	11	11	0	30
810	0	0	5	9	1	15
855	0	0	1	1	1	3
Total	2	26	28	25	2	83

h = 854
s_h = 40 7
a = 756
s_a = 40 1
r = .51



1. AEDES AEGYPTI



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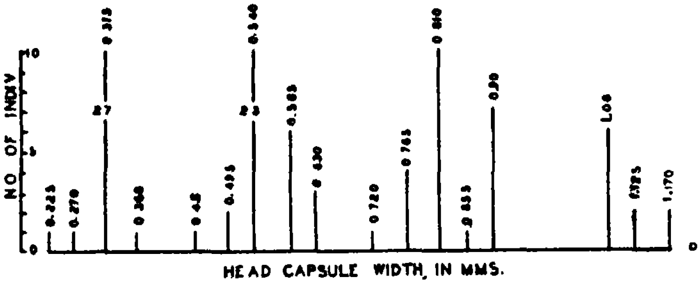
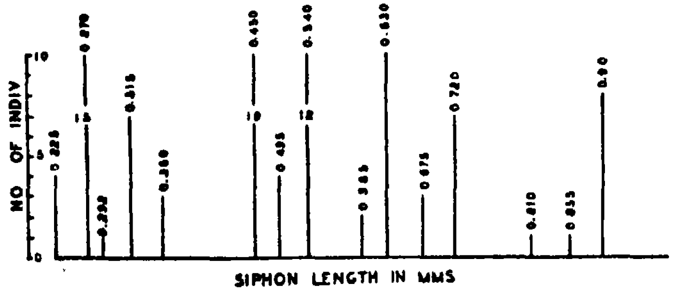


3. AEDES TRIVITTATUS



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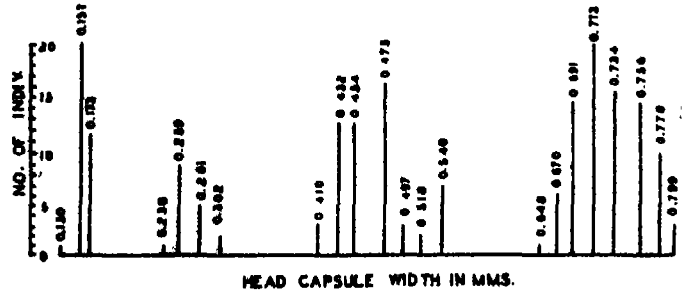


5. ANOPHELES QUAD.

FIGS. 1–5. Histograms of the head capsule widths and air siphon lengths of *Aedes aegypti*, *Aedes trivittatus* and *Anopheles Quad.*

TABLE II

Aedes trivittatus

INSTAR 1

Air Siphon	Head Capsule Width				Total
	225	270	315	360	
225	1	0	3	0	4
270	0	1	14	0	15
292	0	0	1	0	1
315	0	0	7	0	7
360	0	0	2	1	3
Total	1	1	27	1	30

h = 312
s_h = 20 2
a = 284
s_a = 37 6
r = 42

INSTAR 2

Air Siphon	Head Capsule Width					Total
	450	495	540	585	630	
450	1	2	14	4	0	21
495	0	0	1	1	0	2
540	0	0	8	1	3	12
Total	1	2	23	6	3	35

h = 550
s_h = 36 3
a = 483
s_a = 42 7
r = 57

INSTAR 3

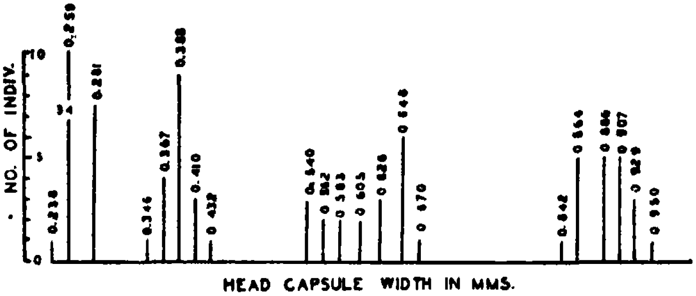
Air Siphon	Head Capsule Width					Total
	720	765	810	855	900	
585	0	1	1	0	0	2
630	1	1	6	0	2	10
675	0	1	0	0	2	3
720	0	1	3	0	3	7
810	0	0	0	1	0	1
Total	1	4	10	1	7	23

h = 828
s_h = 55 5
a = 667
s_a = 55 4
r = .32

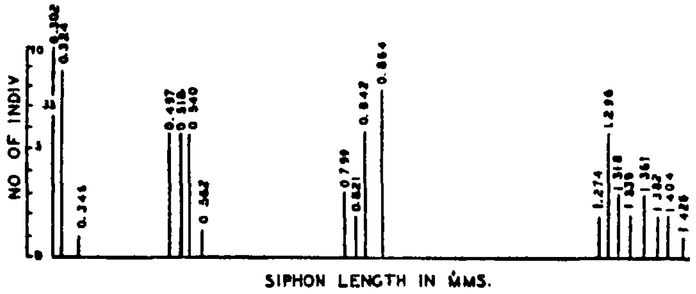
INSTAR 4

Air Siphon	Head Capsule Width			Total
	1080	1125	1170	
810	1	0	0	1
855	1	0	0	1
900	4	2	2	8
Total	6	2	2	10

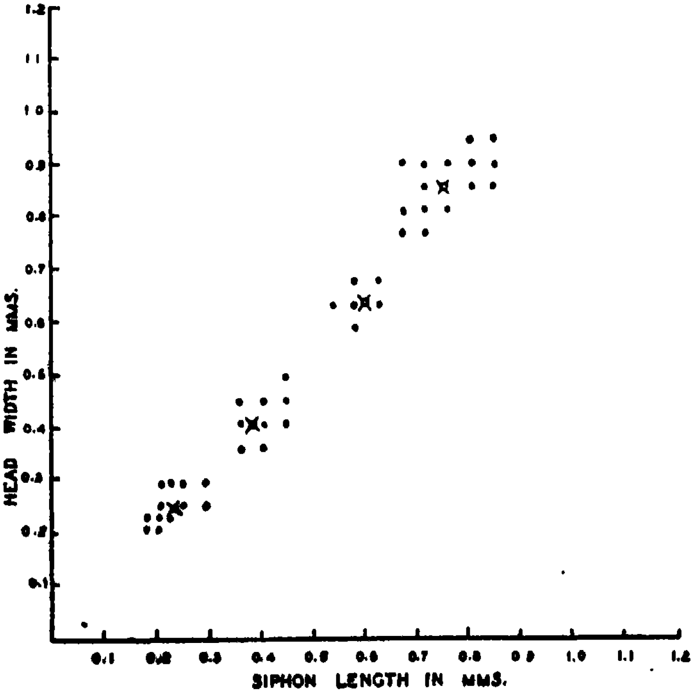
h = 1107
s_h = 37 9
a = 887
s_a = 30 4
r = 35



6. CULEX APICALIS



7 CULEX APICALIS



8. AEDES AEGYPTI

FIGS. 6–7. Histograms of the head capsule widths of air siphon lengths of *Culex apicalis*.
FIG. 8. Scatter diagram of *Aedes aegypti*.

TABLE III

Culex apicalis

INSTAR 1

Air Siphon	Head Capsule Width			Total
	238	259	281	
302	1	32	0	33
324	0	2	7	9
346	0	0	1	1
Total	1	34	8	43

h = 262.7
s_h = 9 33
a = 307.9
s_a = 10 6
r = 81

INSTAR 2

Air Siphon	Head Capsule Width					Total
	346	367	388	410	432	
497	0	2	4	0	0	6
518	0	2	1	2	0	5
540	1	0	4	1	0	6
562	0	0	0	0	1	1
Total	1	4	9	3	1	18

h = 387 6
s_h = 20 2
a = 520 8
s_a = 20 8
r = 33

INSTAR 3

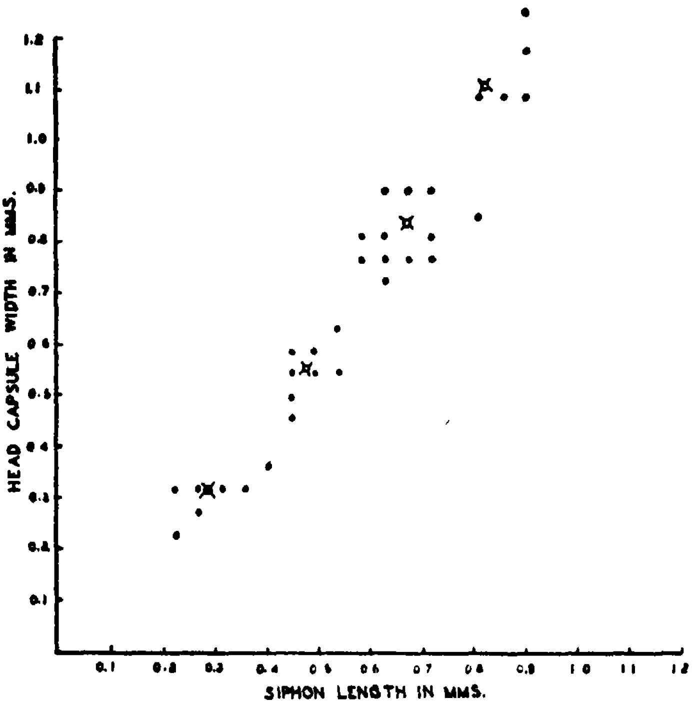
Air Siphon	Head Capsule Width							Total
	540	562	583	605	626	648	670	
799	1	2	0	0	0	0	0	3
821	1	0	0	0	1	0	0	2
842	1	0	1	1	2	1	0	6
864	0	0	1	1	0	6	1	9
Total	3	2	2	2	3	7	1	20

h = 610 2
s_h = 27 7
a = 843.5
s_a = 237
r = 237

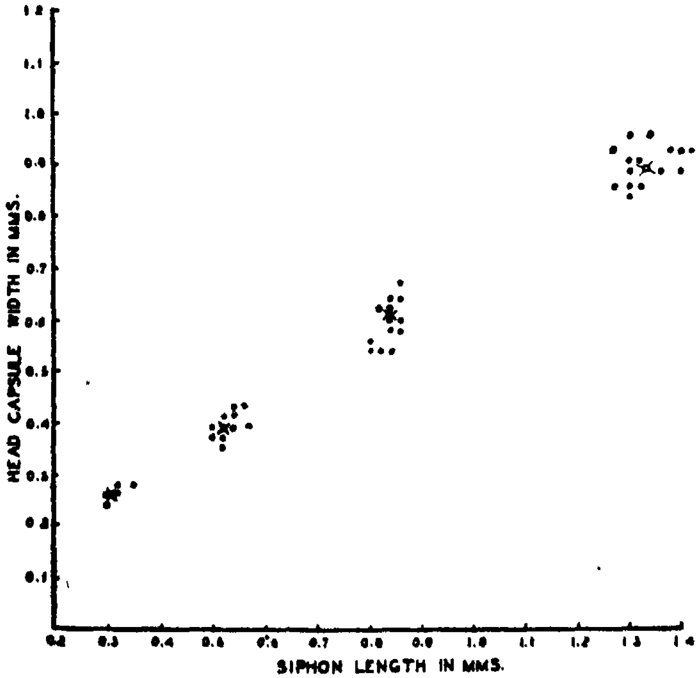
INSTAR 4

Air Siphon	Head Capsule Width						Total
	842	864	886	907	929	950	
1274	0	2	0	0	0	0	2
1296	1	2	1	2	0	0	6
1318	0	1	0	2	0	0	3
1339	0	0	0	1	0	1	2
1361	0	0	3	0	0	0	3
1382	0	0	0	1	1	0	2
1404	0	0	1	0	1	0	2
1426	0	0	0	0	1	0	1
Total	1	5	5	6	3	1	21

h = 893.8
s_h = 27.7
a = 1335.1
s_a = 45.6
r = .56



9.AEDES TRIVITTATUS



10 CULEX APICALIS

FIGS. 9–10. Scatter diagrams of *Aedes trivittatus* and *Culex apicalis*.

In the case of the larvae of *C. apicalis*, *An. quadrimaculatus* and *Ae. aegypti* the instars of each species were mixed together and withdrawn at random for measurement. The larvae of *Ae. triviltatus* were taken from predetermined instar groups. One hundred and two examinations were made in the case of *C. apicalis*, one hundred and ninety-six of *An. quadrimaculatus*, one hundred and ninety-two of *Ae. aegypti* and ninety-eight of *Ae. triviltatus*.

Measurements were made of the head capsules of the four groups represented in the region of greatest width, which occurred commonly between the ocular areas.

TABLE IV

Anopheles quadrimaculatus

INSTAR 1

Head Capsule Width			Total	
130	151	173		
1	21	12	34	h = 158.2 s_h = 11.5

INSTAR 2

Head Capsule Width				Total	
237	259	281	302		
1	9	5	2	17	h = 269.4 s_h = 17.3

INSTAR 3

Head Capsule Width							Total	
410	432	454	475	497	518	540		
3	13	13	17	3	2	7	58	h = 467.8 s_h = 36.1

INSTAR 4

Head Capsule Width								Total	
648	670	691	713	734	756	778	799		
1	6	15	21	16	15	10	3	87	h = 727.2 s_h = 34.8

The air siphons were measured from the point of juncture at the eighth abdominal segment to their tips.

Tables I-IV comprise a presentation of the head capsule and air siphon measurements in the form of frequency tables. The measurements are rounded off to three places and recorded in thousandths of a millimeter. Together with the frequency table will be found the means, standard deviation of the two variables and correlation coefficient.*

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*The tables and statistical analysis included herein were prepared by the Statistical Laboratory, Ohio State University, Columbus, Ohio.

From the data in Tables I–IV, Table V has been compiled The ratios refer to the ratio between the weighted mean of one instar and that of the preceding one. Difference refers to the differences between the weighted means.

TABLE V

	Head Capsule Width			Air Siphon Length		
Instar	Mean	Difference	Ratio	Mean	Difference	Ratio
			Aedes aegypti			
1	246			231		
2	402	156	1 634	388	157	1 680
3	635	233	1 580	601	213	1 549
4	854	219	1 345	756	155	1 258
			Aedes trivittatus			
1	312			284		
2	550	238	1 763	483	199	1 701
3	828	278	1 505	667	184	1 381
4	1107	279	1 337	887	220	1 330
			Culex apicalis			
1	263			308		
2	388	125	1 475	521	213	1 692
3	610	222	1 572	844	323	1 620
4	894	284	1 466	1335	491	1 582
			Anopheles quadrimaculatus			
1	158					
2	269	111	1 703			
3	468	199	1 740			
4	727	259	1 553			

DISCUSSION OF DATA

The distribution of the measurements of both the head capsule widths and air siphon lengths were plotted from the data in Tables I–IV. In addition, scatter diagrams were made by plotting the head capsule widths against the siphon lengths for *Aedes aegypti*, *Ae. trivittatus* and *Culex apicalis*.

Upon examination of the histograms (Plates I and II, Fig. 1–7) of both the head capsule widths and air siphon lengths it becomes apparent that these measurements are relatively constant within the four stadia. This observation corresponds with that of Dyar (1890) who, in his study of lepidopterous larvae, found in those examined that the sclerotized parts did not change in area during a stadium but rather the change occurred with ecdysis. In all cases, except the air siphons of the third and fourth instars of *Aedes aegypti*, there is a marked difference between the extremes.

It is considered that the accompanying scatter diagrams (Plates II and III, Fig. 8–10) serve to sum up the entire situation rather adequately. When length of siphon is plotted against head width for all individuals in each instar, it becomes readily apparent that both increase in a definite, clear-cut manner with ecdysis and that no overlapping of extremes occurs except in the case of the air siphons of the third and fourth instars of *Aedes trivittatus*.

Gaines and Campbell (1935) in their study of the number of instars in the corn earworm, *Heliothis obsoleta* (Fab.), used the ratio of the means of measurements of successive instars as a means of judging the progression of head capsule widths. They found, as did Ripley (1930) and Forbes (1934) with other lepidopterous larvae, that the greatest proportionate growth tended to fall between the first and second instars and the least between the pennultimate and the last. This also appears to hold true for the four groups of larvae considered here. An exception does occur in the head capsule ratios of *An. quadrimaculatus* and *C. apicalis* in which the ratios of the second and third instars are greater than those of the first and second instars; however, since the other five sets of ratios show a consistent decrease in ratio and since in no case is the last ratio greater than those preceding it, an experimental error rather than a deviation from the expected trend may be inferred.

The coefficients of correlation (r) indicate only a low degree of correlation between the size of the head capsules and air siphons. From this evidence it is not possible to predict size of an individual head capsule from the size of the air siphon or vice versa within a stadium.

Although there is an apparent and distinct increase in head capsule width and air siphon length between each instar and its succeeding one, it is not possible to state the nature of this increase in terms of regular progression, either geometric or arithmetic. This condition may be due to the fact that our time increment was determined arbitrarily and not with consideration of the time spent by each individual larva in each of the four stadia.

For practical purposes, the means of the head capsule widths of all the species studied and the air siphon lengths of the culicid species may be used as a criterion for determination of the instar. Although the character of the head capsule is known to be used by many field workers as an indication of instar, no stated corroboration of this practice was found in the literature in hand.

SUMMARY

The head capsule widths and air siphon lengths of the species of mosquito larvae herein examined are relatively constant within the four stadia. There was, with one exception, no overlapping of the extremes of measurements between instars.

The ratio between means of measurements of successive instars tends to decrease with the advancement of the larval instars.

Correlation is low between the size of head capsule and air siphon within an instar.

Determination of the nature of the rate of growth during successive molts cannot be completely assayed without an accurate determination of the time spent by each larva in each stadium.

For practical purposes the width of the head capsule and/or the length of the air siphon in each of the species considered may be used in determination of the stadia and number of instars.

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THE ORIGIN OF PETROLEUM IN THE LIGHT OF RECENT RESEARCH

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The story of the formation of crude petroleums and natural gas is not only an intriguing, scientific puzzle, or rather a series of scientific puzzles of general chemical and geological interest, but it is of the greatest practical importance to petroleum geologists. If we knew the entire story it would enable us to understand why large continental areas are entirely without accumulations of petroleum of commercial importance and why, in certain areas, perfectly good geological structures favorable to the accumulation of petroleum have been drilled and no petroleum or natural gas whatever has been found. A great deal of geological and chemical knowledge has been accumulated, particularly in recent years, and some of the questions in regard to the origin of petroleum and natural gas can now be definitely answered; other facts still await definite or plausible answers. Our knowledge of the subject to date represents a vast amount of investigation by a great many able chemists, geologists and others, and the general overall problem still includes many unsolved questions, the answer to which will require much more work and the best thought of the best minds.

I believe that our present knowledge enables us to draw certain conclusions which should be helpful to petroleum geologists and should be helpful to chemists and refiners in understanding the nature of crude petroleums with which they have to work. It is not too much to say that study of this problem now enables us to predict with fair assurance the nature of a crude petroleum which might be expected when drilling to various depths into oil-producing strata of different geological ages. If it is known beforehand at about what depth a particular producing sand is to be expected, we may be reasonably sure of the kind of crude we will find. There are some exceptions to this and the reasons for these exceptions are also significant and are part of the story.

The following diagram indicates approximately what the distribution of carbon is in the lithosphere (Fig. 1), which is as far as our knowledge goes. The relative proportions of carbon locked up in carbonate rocks, particularly limestones and dolomites, coal and petroleum, is roughly indicated. The carbon in oil shale was overlooked but should be a figure somewhat greater than that for oil. The source of the carbon dioxide before it was locked up in these carbonate rocks and, through animal and plant organisms, in oil shale, coal and petroleum is another story involving the source and nature of the earth's primitive atmosphere.

It is apparent that no figures for these quantities of carbon can be really accurate but their *relative* magnitude approximately, is as follows:

Carbon in carbonate rocks	2,310,000
Carbon as CO_2 and CO_3 in sea water	2,180
Carbon in coal	1,200
Carbon as CO_2 in air	68.
Carbon in petroleum	4.2

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The latter figure is based upon an estimate of the world's ***known*** recoverable reserves made for the Government during the last war. The actual figure may be twice or three times this figure (or about 150 billion barrels).

FUNDAMENTAL GEOLOGICAL CONDITIONS

Although the aspects of the origin of petroleum and natural gas which we are discussing here are mainly chemical,-we must first consider a little geological history and the fundamental conditions which geology imposes upon us in considering the problem. Thus geology gives us the framework as to time, temperatures and pressures, the original environment and present environment, and probable nature of the original source material of petroleum, within which set of conditions we must work out the story of petroleum formation.

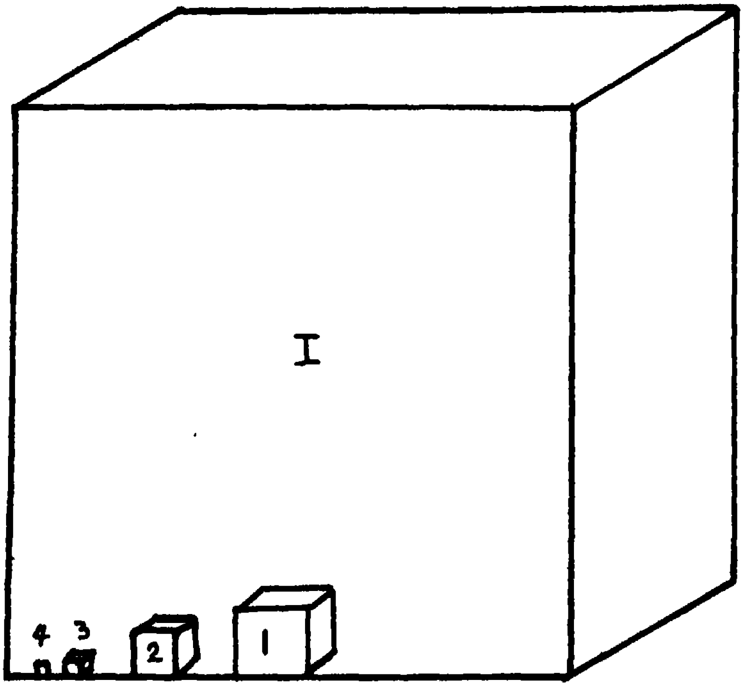


FIG. 1. Distribution of carbon, according to J. G. Bennett.
I. Carbonate rocks.
1. CO_2 in Sea water. 2. Coal. 3. CO_2 in atmosphere. 4. Petroleum.

Most of the theories proposed by chemists for the origin of petroleum and natural gas have neglected to take into account these fundamental conditions which have been by now firmly established by petroleum geologists, and most of them must be rejected because they do violence to and cannot be reconciled with these fundamental conditions. As stated by Beeby Thompson (2), "In seeking the origin of petroleum one must not introduce extraordinary theories for its occasional occurrence amongst unusual surroundings, but consider only such views as will account for its extensive production and wide distribution by common processes of nature."

At this point we may refer to a simplified geological column, Fig. 2, which shows the order in which the sedimentary rocks of the different periods were laid down. By the study of radioactive minerals in intrusive rocks, such as pegmatites,

	GEOLOGICAL SCALE	AGE IN MILLIONS OF YEARS	OIL FIELDS
Quaternary			
Tertiary	Pleistocene		Caucasus, Iran, Irak
	Pliocene		California
	Miocene	13 ± 1	Gulf Coast Salt Domes
	Oligocene Eocene Poleocene	18 ± 1.5 34 ± 2	Venezuela, Colombia Trinidad
Mesozoic	Cretaceous	57 ± 1.5	Texas, East Texas Rodessa field Woodbine sand
	Jurassic	85	Mexico
	Triassic	165 Palisades Uplift 180 Watchung Mts.	
	Permian		West Texas and Eastern New Mexico
	Carboniferous	230 ± 15	U. S. Appalachian Michigan Illinois
Paleozoic	Devonian	300	Midcontinent
	Silurian	Adirondacks 370 ± 30	Ohio-Indiana
Eozoic	Ordovician		Wilcox Sands of Midcontinent
	Cambrian	400	
	Kewenowan	535 ± 25	

FIG. 2. Time or geologic age based upon a study by W. D. Urry and others from the study of radioactive minerals in pegmatite intrusions.

we now know fairly accurately the age of these sedimentaries in terms of millions of years. Beginning with the top of the Cambrian series with an age of about four hundred million years, we come down to the most recent periods containing petroleum, to the Pliocene, geologically very recent with an age of about ten to twelve million years. This simplified geological column is drawn to a scale proportional to time and bears no relation to the thickness of the strata in the various series. Approximately two-thirds of our current oil production and known reserves occur in the Cretaceous and above.- The reason for this is that by this time the continental areas had become much more extensive and the erosion from these continental areas resulted in the deposition of thick marine sediments, and where this erosion and deposition took place relatively rapidly in lagoons or large basin areas or, in some cases, along shore lines, we then have the first basic requirement for the ultimate production of petroleum and natural gas.

There are three general types of organic matter found in large quantities practically throughout this geological column; they are, coal, the so-called kerogen in oil shales, and petroleum and natural gas. Coals are generally believed to have been derived from quite different source material than kerogen, petroleum and gas, and evidently were fresh water or marsh deposits derived from lush vegetation, and cellulose, lignins and resins constitute the principal source material. The original organic source material of kerogen, petroleum and natural gas, was laid down in *marine* and in fresh water sediments.

The original organic source material which resulted in the formation of kerogen and of petroleum and natural gas is still uncertain and may have varied somewhat. Shales, in general, are deep water deposits whereas sandstones and limestones are laid down at relatively shallow depths. It is a striking fact that the so-called kerogen of oil shales has persisted, apparently unchanged, from geologic times as remote in certain cases as the upper part of the Cambrian series, or about four hundred million years. In other words, there is no evidence that the temperatures and other conditions normally prevailing in any of these old strata has ever decomposed kerogen or converted it to oil. Most oil shales contain no petroleum whatever, and others only very minor proportions. Oil shales containing kerogen may be as much as four hundred million years old, as the New Brunswick oil shale, (9) or the extensive black shales of New York, Ohio and Michigan, which are Devonian. Yet petroleums may be as recent as the Pliocene as, for example, those from the Midway fields of California. The original organic source material of both oil shale and petroleum was at least associated with, and probably derived from, at least in part, green algae, since Treibs (28) has found chlorophyll porphyrine in all oil shales examined by him and in all petroleums containing asphalt or, in other words, in all petroleums not purified by selective adsorption during migration. This discovery of chlorophyll porphyrins is undoubtedly the most important single discovery bearing upon the question of petroleum origin. It definitely connects up both oil shales and petroleum with green algae and proves that both have never been at any time in their history subjected to high temperatures and, in agreement with other evidence, shows that the original organic source material was deposited sufficiently rapidly to seal in the organic debris under anaerobic conditions. Certain oil shales studied by Treibs contain half as much chlorophyll porphyrin material as can be derived from dried green leaves. All sorts of marine animal and vegetable life probably contributed to the organic debris deposited in the original ocean sediments. Several years ago, the American Petroleum Institute conducted extensive investigations under the direction of Parker D. Trask into contemporary sediments currently being deposited in various parts of the oceans. These investigations found no petroleum in these sediments and do not throw much light on the nature of the organic material contained in them. The kerogen of oil shale is a highly complex material, evidently in a highly polymerized condition as indicated by its insolubility in all organic solvents at ordinary temperatures.

It can be extracted by solvents only at temperatures at which it begins to be decomposed. Fatty oils found in very recent deposits of decaying algae have been found to be already in a partly polymerized condition.

As might be expected from considerations of the original environment and original organic source material of kerogen, oil and gas, and coal, there are deposits of fossil organic material which are difficult to classify and fall in between the three typical major materials just named. Thus there are oil shales which are very rich in organic material yielding upwards of a hundred gallons of oil per ton and include the type of shales known as torbanites. Closely related to these are the cannel coals which contain a high percentage of organic material yielding oils and paraffins by destructive distillation. In fact, the low temperature destructive distillation of coals, particularly those of the cannel coal type, yield distillates rich in paraffins and unsaturated hydrocarbons and, in general, such distillates are not very different from shale oil. Typical oil shale yields oil consisting mainly of paraffins, naphthenic hydrocarbons, and unsaturated hydrocarbons, but also relatively large proportions of phenols, nitrogen bases, ammonia and sulfur derivatives. Typical petroleums also contain complex substances which are decomposed on heating to give phenols and sulfur derivatives such as the mercaptans, thio-ethers and thiophenes which are not present in the original crude but are decomposition products of thermo-labile complex substances in the crude. Similarly, crude petroleums contain complex nitrogenous material which is decomposed at moderate temperatures to give nitrogen bases found, for example, in the kerosene distillates in small proportions of all petroleums. Also, the naphthenic acids found in the distillates are almost wholly formed by the decomposition of more complex material in the original crude oil. Cracked gasolines contain small proportions of phenols and these have sometimes been industrially recovered from cracked gasolines. The proportions of these so-called impurities, phenols, naphthenic acids, nitrogen bases and sulfur derivatives, are much smaller in cracked gasoline than in shale oils and distillates made by the low temperature carbonization of coal, but their presence is indicative of the same or similar substances in the crude materials.

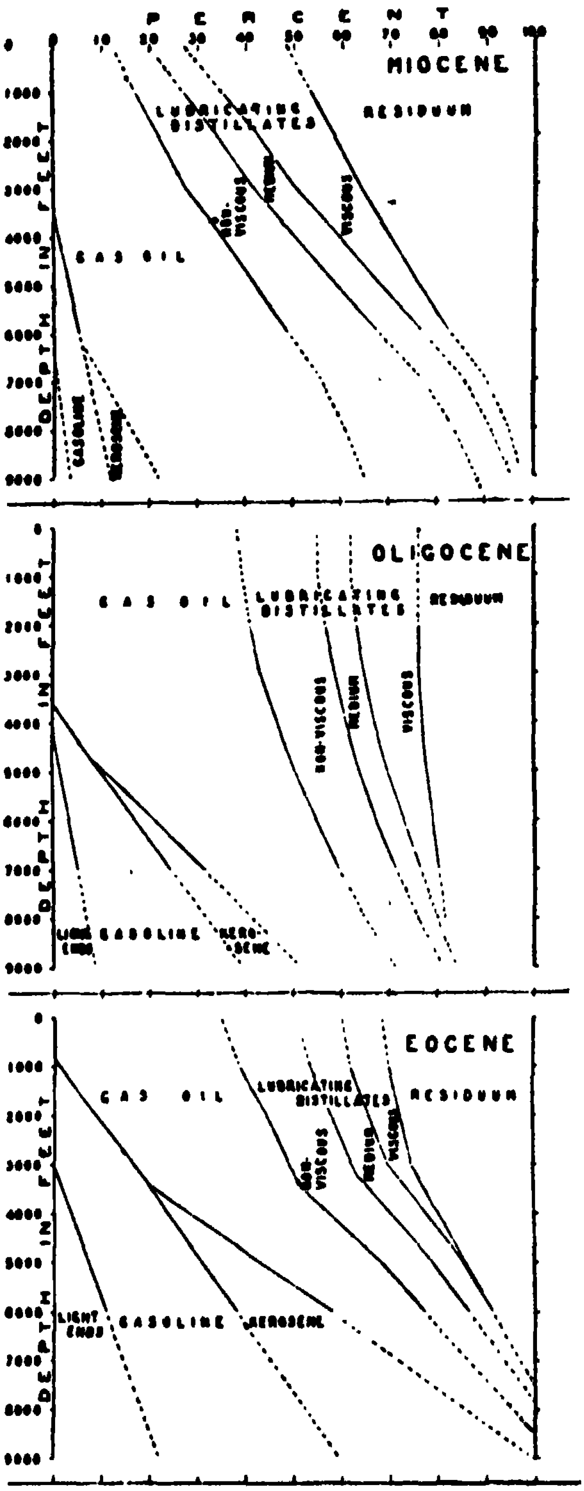
The existence in crude petroleums of these thermo-labile complex substances which yield mercaptans and other sulfur derivatives, naphthenic acids, nitrogen bases, together with the presence of chlorophyll porphyrins show that petroleums have never been subjected to very high temperatues at any time during their history. (6) This chemical evidence of low temperature history is consistent with the evidence of low temperatures derived from the actual measurement of bottom-hole temperatures in oil fields, the consideration of temperature gradients in oil fields and general geological considerations.

LACK OF KNOWLEDGE OF PETROLEUM IN TRANSITION STAGES

Referring again to the simplified geological column, no petroleums or other bituminous material has been investigated chemically which is more recent than the Midway-California oils from Pliocene sands in California. In other words, there is at present a complete gap as regards the transformation of organic matter in contemporary sediments into petroleum, between the Pliocene of about ten million years ago and the sediments now being deposited. It should be expected that a satisfactory chemical history of this transformation could be found by the examination of organic material in intermediate states. Such material certainly exists and awaits study. The organic matter in the sediments is solid, or semi-solid, and has to be in order to be retained in the sediments as they are laid down. Such material in intermediate stages, before it has become fluid enough to flow, migrate and collect in so-called pools, would be disseminated through the geologically recent sands or shale, and would have to be recovered by extraction. A few years ago, Donald C. Barton, (1) Petroleum Geologist of the Humble Oil Company, as a result of a study of Gulf Coast petroleums and the relations between their composition and geological age and depth, arrived at this conclusion merely by extrapolation when the data was plotted geographically.

The heavy, black, tarry oils in geologically recent tar sands should repay investigation as possibly being petroleum in very early transition stages of formation. At some early stages geologically recent natural bitumens might be expected to show a much higher content in organic acids than typical petroleums. The observation of Pyhala (18) that in the case of two Russian oils, the distillates showed 11 to 12 times as much naphthenic acids as the original crudes suggests that determination of saponification numbers on crude petroleums, particularly heavy naphthenic, geologically recent oils and tars would probably show much higher saponification numbers in the recent material. The organic nitrogen content would also be of interest. There are reasons, mentioned later, for expecting that such transition material would show substantial olefinic unsaturation, perhaps unsaturated fatty acids or their polymers.

Barton's studies are shown in the accompanying graphs, Figures 3, 4 and 5. It has long been recognized that, in general, the light crudes containing much



FIGS. 3-5. Composition of Gulf Coast oils, plotted graphically according to D. C. Barton.

gasoline and generally paraffinic in type, are geologically much older than the heavy, asphaltic crudes containing little or no gasoline. Barton's study of the Gulf Coast oil was the first systematic investigation bearing on this point. Subsequent investigations in the Gulf Coast area have shown that the relations are not so simple as indicated by these graphs, but the general results or the average of the results are as shown by Barton. In other areas, notably in Wyoming and California, the relations found by Barton do not hold very well, but many of the apparent exceptions are due to changes in the crude oil by selective adsorption in migration.

TEMPERATURE IN OIL FORMATION

The subject of temperature as a factor in petroleum formation has been very frequently discussed since it was first suggested by Warren and Storer in 1863 and later in 1888 by Engler, (10) that petroleums resulted from a destructive distillation of fatty oils derived from fish or other marine life, but it has become increasingly difficult to reconcile such a process with the chemical and geological evidences of low temperature history.

We now know a good deal concerning the individual hydrocarbons present in petroleums, particularly in the gasoline and lighter kerosene fractions. This information, which has largely been a result of about twenty years of investigation by the U. S. Bureau of Standards (19) as a research project financed by the American Petroleum Institute, is summarized in the following tables. (22) Consideration of the composition of these gasolines permits the conclusion to be drawn that they are not equilibrium mixtures corresponding in composition to any particular thermal condition.

TABLE III

HYDROCARBON TYPES IN STRAIGHT-RUN GASOLINES

CRUDE OIL	END POINT (° C.)	PER CENT BY WEIGHT OF		
		Aromatics	Naphthenes	Paraffins
Oklahoma City, Okla	177	10	29	61
Tonkawa, Okla	150	9	35	56
" "	210	12	37	49
Davenport, Okla	150	8	28	64
" "	210	11	28	61
East Texas	159	6	42	52
Mexia, Texas	150	22	21	57
" "	210	18	21	61
Rodessa, La	160	10	20	70
Santa Fe Spr., Cal	151	10	50	40
Kettleman Hills, Cal	151	8	45	47
Signal Hill, Cal	153	6	52	42
Huntington Beach, Cal	155	7	49	44
" " "	210	11	54	35
Turner Valley, Canada	150	11	38	31
" " "	200	15	35	50

TABLE IV

CHEMICAL COMPOSITION OF LIGHT PARAFFIN-NAPHTHENE FRACTION, 40° TO 102° C. OF U. S. STRAIGHT-RUN GASOLINES

GASOLINE	PERCENTAGE BY VOL.			
	Normal Paraffins	Isoparaffins	Cyclopentanes	Cyclohexanes
Ponca, Okla	35.7	20.5	23.4	20.4
East Texas	24.7	27.3	26.0	22.0
Bradford, Pa.	34.4	32.2	13.4	20.0
Greendale-Kawkawlin, Mich	63.1	13.2	8.0	15.7
Winkler, Texas	9.5	61.6	8.4	20.5
Midway, Cal.	10.0	21.5	41.0	27.5
Conroe, Texas	18.2	20.3	17.3	44.2

The aromatic content of the gasoline, distilled up to 180° C. from the same crudes is as follows:

TABLE V

CONTENT OF AROMATICS IN U. S. STRAIGHT-RUN GASOLINES (E. P. 180° C)*

Gasoline	Aromatic Content (% by weight)
Ponca, Okla	9.8
East Texas	10.4
Bradford, Pa	8.3
Greendale-Kawkawlin, Mich	7.2
Winkler, Texas	4.9
Midway, Cal	8.0
Conroe, Texas	27.6

Dr. Frederick Rossini, under whose direction much of this analytical study was made, and in my opinion the analytical results are beyond question, has recently pointed out that the relative proportions of certain *selected* groups of constituents correspond approximately to the proportions required by thermal equilibrium at about 400° C. or 752° F. (20). Dr. Rossini stated that this would have to be taken into account in any theory of the formation of petroleum. However, the geological history and other chemical evidence must be taken into account. Also, it should be pointed out that all of the analyses are taken into account, it is apparent that these gasolines do not represent thermal equilibrium mixtures. At temperatures below about 200° C. thermo drynamic considerations teach that the iso-paraffins are more stable than the normal paraffins. Yet the gasoline fraction from Michigan crude contains 63.1 per cent of normal paraffins and 13.2 per cent of iso-paraffins. In contrast to this, the gasoline from Winkler crude contains 95. per cent normal paraffins and 61.6 per cent of iso-paraffins. The gasoline from Yates, Texas, crude is reported to contain no normal paraffins. The Michigan crude is geologically much older than the Winkler crude and both are obtained from wells whose bottom-hole temperatures are below 100° F.

The above tables also show the greatest variation in the relative proportions of cyclopentanes and cyclohexanes and there is no simple relation between the proportions of cyclohexanes and aromatic hydrocarbons. There is no indication that the aromatic hydrocarbons have been derived from cyclohexanes by catalytic dehydrogenation. It will be noted that the gasoline from Conroe crude, containing 27.6 per cent of aromatics is entirely out of line with all the others studied and is quite unlike gasolines from other crudes of similar geologic age, depth of producing strata, and observed bottom-hole temperatures.

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* Possible deviations from the above figures ±0.2 to 0.5.

If petroleums were produced from the original organic source material by thermal action *alone*, then oils of similar age and similar temperature history should have the same composition, but this is not even approximately true. The following table gives the approximate age, observed bottom-hole temperatures and depth of the producing formation for the seven crudes investigated by the Bureau of Standards. The highest bottom-hole temperature is that of the Conroe field where the temperature at 4,900 foot depth is 172° F. In the Permian basin of West Texas, the temperature is only 126°F. at 5,900 feet below sea level. In the East Texas field, the producing formation is the Woodbine sand of the Cretaceous producing from a depth of 3,300 feet below sea level and a bottom-hole temperature of about 146° F. Oils of the Permian basin of West Texas are much older than either the Conroe or East Texas oils.

The temperature history of petroleum begins with the temperature at which the original source sediments are laid down in the ocean, probably an average of 60–70° F. As the despoits build up in thickness they serve as an insulating blanket and in the course of time the temperature slowly rises as the thickness of the strata or depth increases. The temperature gradients in the various oil fields varies from about 50 feet to 100 feet for each increase in temperature of one degree Fahrenheit. (13) The present observed bottom-hole temperatures probably represent the maximum temperature for the entire geologic history of a particular producing formation, except in old regions which have been highly eroded and where the producing sands are now near the surface. McCoy and Keyte (16) state that "most of the known oil fields surely were formed at temperatures lower than 140° F." Some of our most prolific fields yield oil from formations whose bottom-hole temperatures do not exceed 100° F. At Oklahoma City, a temperature of 100° F. is found at 4,100 feet.

Barton states: "The geologic history of the Gulf Coast is relatively simple. It is quite impossible that the Gulf Coast crude oils which are now being produced have been subjected to temperature as (high as) 100° C. Some of the crude oil from the deeper sands may have been subjected to temperatures as high, but not much higher than 70° C. Much of the crude oil cannot have been subjected to temperatures much higher than 50° C.—the normal average crude oil is indigenous to the formation in which it is found and has not migrated up from greater depth."

Since the straight run gasolines that have been most carefully analyzed are those noted in the above tables, the following data are given for these crudes:

TABLE VI

Geological and Field Data for Selected Crudes

Field, Source of Crude	Producing Sand	Series	Depth, Average Feet	Bottom Hole Temp. °F.	Estimated Age in Million Years*
Ponca, Okla	Wilcox	Middle Ordovician	3,872	139°	360–380
East Texas	Woodbine	Cretaceous	3,300	146°	60–80
Bradford, Pa	Bradford	Devonian (Chemung)	2,000	72°	300
Greendale, Mich	?	Middle Devonian	5,300	96°	300
Winkler, Texas	Big Lime	Permian	3,000	85°	200–230
Midway, Cal		Pliocene	2,050	115°	10–13
Conroe, Texas	Cockfield	Eocene	4,900	172°	40–50

* Based upon estimates by W. D. Urry and others from the study of radioactive minerals pegmatite intrusions.

CATALYTIC ACTION OF ACTIVE SURFACE MINERALS

The low temperature history of petroleums must be considered as firmly established by the field observations and the geological and chemical evidence.

However, we must consider the evidence that petroleums do change. Heavy, asphaltic, naphthenic oils change to lighter, more paraffinic oils and contain more light constituents, such as gasoline, as these changes proceed. We must also consider the great complexity of petroleums and the very large number of hydrocarbons present, beginning with the gases, methane, ethane and propane, et cetera, up to and including mixtures of high boiling hydrocarbons which are beyond our power of analysis and identification. It has been calculated, (23) by employing the velocity constants for cracking, that at 212° F. the higher paraffins have a stability greater than the element potassium, and according to these calculations, the paraffins would remain substantially unchanged if maintained at 300° F. throughout geologic time from the middle Ordovician to the present. These facts can be reconciled, however, if we suppose that *clays and possibly other minerals common in the strata in contact with petroleums have a catalytic action, at the observed relatively low temperatures, on the crude oil and on the heavy bituminous material formed in the early stages of oil formation.* That clays and certain other minerals may have such a catalytic effect is indicated not only by the evidence just noted, but also by the fact that certain natural clays and special silica-alumina catalysts and silica-magnesia catalysts are industrially employed in catalytic processes at relatively high temperatures, 850–950° F. and that at low temperatures many of these clays and minerals show very high catalytic activity with respect to the polymerization of unsaturated hydrocarbons. Clays such as Fuller's earth are capable of polymerizing iso-butene at temperatures as low as —100° C. and, in general, the lower the temperature the higher the molecular weight of the polymers formed. 2-Butene is 85 per cent polymerized by Fuller's earth on standing four months at room temperature. This property of polymerizing unsaturated hydrocarbons is not limited to Fuller's earth but, as pointed out in an earlier paper by the writer, is a general property common to all clays and rocks containing clay. Very reactive hydrocarbons such as trimethyl ethylene, isobutene and pinene are polymerized at room temperature with evolution of heat by clays, not of the Fuller's earth type, bentonite, bauxite, sandstones and green-sand, although the activity of silica gel and pure kaolin is very slow.

The specimens of sedimentary rocks from Oklahoma which were tested for polymerizing activity are shown in the following table: (6)

POLYMERIZING EFFECT OF OKLAHOMA SEDIMENTARY ROCKS AND SOME MINERALS ON TURPENTINE

Mineral	*Per Cent Polymer*
Fuller's earth of Georgia	75
Sylvan shale	76
Red-bed clay	65
Tertiary clays	68
Greensand, New Jersey	72
Greensand, Texas	70
Serpentine, Easton, Pa	60
Gray Persian sandstone	56
Stanley shale	57
Regan sandstone	50
Calvin sandstone	46
Simpson sandstone	34
Permian sandstone	30
Bentonite	34
Bauxite, Georgia	58
Silica gel	23
Kaolin	12
"Glaucosil" (acid leached greensand)	45

Mineral	*Per Cent Polymer*
Prehnite (zeolite)	None
Stilbite (zeolite)	None
Talc	None
Infusorial earth	None
Powdered pumice	None
Ferric oxide, pure	None
Aluminum oxide, pure	None

It will be noted in the above table that the six typical sandstones tested show a catalytic activity as indicated by polymerization averaging better than half the catalytic activity of typical Fuller's earth and that three Oklahoma clays showed activity very nearly as high as typical Fuller's earth. Even bauxite, which can have only a very small percentage of clay as an impurity, shows about two-thirds the plymerizing activity of Fuller's earth. It is indicated by these results that catalytic activity is not limited to acid clays, but is due to active surfaces which strongly adsorb the hydrocarbons.

At elevated temperatures different active surface materials show different results in catalytic cracking and other reactions. Thus, in catalytic cracking, the character of the gasoline obtained using a silica-alumina catalyst is different from the gasoline produced by a silica-magnesia catalyst, both at the same operating temperature. The silica-alumina catalyst yields more butens and low boiling material and has a somewhat higher octane number. In a study of the catalytic action of Fuller's earth and other catalysts on propylene it was found (12a) that at 350° C., or well below ordinary cracking temperatures, the product consisted of both isoparaffins and olefins, including many isomeric C_5, C_6, C_7, C_8 and C_9 hydrocarbons (29a). The gasoline thus produced had an octane number of 91. Synthetic aluminum silicate had approximately the same catalytic activity as the best activated Fuller's earth, and a catalyst made up of one per cent alumina on silica was twenty times as active as the best activated Fuller's earth.

These results show that paraffins are formed from olefins, that isomerization and splitting of the hydrocarbon molecules takes place very rapidly at temperatures substantially below cracking temperatures, in fact, high temperatures alone do not produce the same results noted in this catalytic conversion of propylene. Here we note much the same so-called "hydrocarbon dispersion" that is found in the composition of typical petroleums. This action of Fuller's earth and other active surface catalysts *proves* that many of the changes with which we are concerned in accounting for the complexity of petroleums do take place rapidly in the presence of such catalysts at temperatures at which the hydrocarbons are relatively stable, and that the reactions are in some respects different in kind from those resulting from the action of heat alone. The formation of some of the products in the resulting mixture can only be explained in the same way that the numerous products of the alkylation of isoparaffins by olefins are explained.

It is true that the complicated reactions which take place in low temperature alkylation processes occur through the action of reagents such as concentrated sulfuric acid, hydrofluoric acid, and aluminium chloride. Such processes include isomerization, the splitting of hydrocarbons and the synthesis of new ones, molecular rearrangements and so-called hydro polymerization. The mixture of hydrocarbons which results contains no olefins at all and when using isobutane and butenes the mixture contains not only the expected C_8 hydrocarbons, but also pentanes, hexanes, heptanes, nonanes and small proportions of heavier hydrocarbons. These reactions take place at low temperatures, refrigeration being required.

It is now generally accepted that all of these results are best explained by the formation of carbonium ions. The low temperature formation of the great number of hydrocarbons found in petroleum through the action of active surface minerals must have a similar mechanism.

Further evidence that the catalytic active-surface minerals play an important role in the formation of petroleum is found in the nature of the hydrocarbon constituents of typical petroleums. The fact that straight-run gasolines and kerosense contain no unsaturated or olefinic hydrocarbons is a strong indication of this and also the complexity of such oils or, in other words, the very large number of hydrocarbons, isomeric paraffins, naphthenes and aromatic hydrocarbons, has no other plausible explanation. The great number of hydrocarbons present in petroleums was one of the primary considerations of the old destruction distillation theory of Warren and Storer and of Engler, but the relatively high temperatures postulated by Engler, and recently by Rossini, are clearly beyond consideration.

The extremely great differences in the composition of petroleums and the wide variations in the composition of gasoline fractions have been noted and are shown by the above tables. Some differences in petroleums could be expected as a result in differences in composition or types of organic material which constitute the original source material but such differences in source material could still not possibly account for the great number of hydrocarnons which are evidently present in all petroleums. Some recent investigators have called attention to the fact that paraffins are found in nature in many plants, being formed by bio-chemical processes in the living plants. Some unsaponifiable hydrocarbon oil has been found in material extracted from decaying algae. However, it should be pointed out that when paraffins occur in nature, only one or two paraffins are formed and at most, not more than four in any one occurrence, and practically all of them are normal paraffins having an odd number of carbon atoms. They were apparently formed by loss of CO_2 from fatty acids which are found associated with these paraffins. Isomeric paraffins, naphthenes, or aromatic hydrocarbons, have never been found in such cases. In the decay of organic matter containing fatty oils, the hydrolysis to free fatty acids, the formation of insoluble soaps, loss of CO_2 and polymerization has been observed and probably takes place very early in the sequence of changes which form petroleum. But the formation of anything other than a very small number of normal paraffins by any biochemical process, including bacterial fermentation, has never been observed.

Consideration of all the above mentioned facts, and particularly the complexity of petroleum composition, leads directly to the conclusion that petroleum origin involves two general processes, (1) conversion of the organic source material into heavy, bituminous material approaching a hydrocarbon mixture in overall composition and, (2) what might be termed the "chemical dispersion" of this essential hydrocarbon material into the great series of paraffins and isomeric paraffins from methane to the solid waxes and also naphthenes and aromatic hydrocarbons. The very heavy viscous oils, often quite free from the lighter hydrocarbons such as gasoline, probably represent petroleum in a very early transition stage. There are many such tarry oils in the so-called tar sands as, for example, the very heavy asphaltic oil found in the upper sands of the Maracaibo basin.

Barton arrived at a similar conclusion in his study of Gulf Coast oils and their geology. "Evolution of crude oil from an original oil, perhaps something like the heaviest end of the residuum of the present Miocene Gulf Coast crude oils,—. The tentative deduction follows that the ancestral crude oil of the Gulf Coast crude oils was a heavy oil which, under the U. S. Bureau of Mines' method of analysis, would consist of residuum. Oils of that type should be too thick and viscous to move except through open channels. They may never be found in appreciable accumulations and may have to be sought as droplets scattered through the source formation."

In considering this suggestion of the role of the catalytic action of active surface minerals, we may summarize the limitations which appear to be imposed by the geologic history, physical conditions, and possible differences in environment which have to be considered in any attempt to account for the differences in type and composition of petroleums:

1. Maximum temperatures varying from about 100° F. to 250° F.
2. Maximum pressures varying from possibly as low as about 1,500 pounds per square inch to about 6,000 pounds per square inch.
3. Time since deposition of original source sediments varying from about 10 to 350 million years (to middle Ordovician).
4. Contact with clays and sands of varying catalytic effects.
5. Unknown differences in type and chemical composition of original source material.
6. Selective adsorption during migration.

Some of the above named factors have already been commented upon. High pressures have often been assumed to have been a factor in the formation of petroleums. It is very doubtful, however, if pressures have been a factor of any importance. As indicated by observed bottom-hole pressures, these pressures vary from about 1,500 pounds, or even less, per square inch to the higher pressures found in deep wells in the range from about 3,000 to 6,000 pounds per squear inch. The observed pressures are seldom as great as the calculated hydrostatic head corresponding to the depth. Theoretically, the effect of high pressures, if any changes are effected by such pressure, should be to produce heavy oils with increasing depth and increasing pressure, which is just contrary to the facts generally observed. Such pressures as those just mentioned are hardly enough to influence chemical changes in the oi. mixture. Thus it is frequently assumed that pressures would bring about polymerization of any unsaturated hydrocarbons originally present. As against this it may be pointed out that Conant (7) and Peterson found that high pressures up to 15,000 atmospheres did not cause the polymerization of such very reactive, unsaturated hydrocarbons as isoprene and butadiene unless such material had previously been subjected to oxidation with the formation of peroxides which in themselves are well known polymerizing catalysts. They concluded that such high pressures, which are many times greater than those encountered in oil fields, cannot cause polymerization of even such very reactive dienes.

Changes in petroleums by selectife adsorption during migration are well known and need not be reviewed here.

If the catalytic action of active surface minerals, such as clays, has been a factor in producing the chemical changes noted by Barton in the Gulf Coast fields as mentioned above, then it might be expected that oils found in reservoir rocks, such as limestones, which have no catalytic action on hydrocarbons might be found to be out of line or inconsistent with the regularities noted by Barton. Once petroleum has migrated into a limestone reservoir rock it should undergo little or no further chemical change. An oil might even have been subjected to such catalytic action and have been converted into a relatively light crude before migrating into a limestone reservoir. Actually we do find many examples of very heavy oils containing little or no light constituents, such as gasoline, occurring in limestone reservoirs even though we would expect from their geologic age and depth that they would be much lighter and more paraffinic. Such oils are the very heavy, asphaltic crudes in Mexico, for example, the Panuco crude which is found in a Cretaceous limestone. A research committee of the Tulsa Geolgoical Society, including H. M. Smith of the United States Bureau of Mines, in a study of Mid-Continent oils (25) has shown that the Arbuckle limestone in southeastern Kansas contains a heavy, asphaltic oil containing none of the lighter fractions, and this is in great contrast to the lighter typical Mid-Continent crudes from much younger formations. The crude oil from the Trenton limetsone of the Lima-Indiana field is much heavier, more naphthenic and contains much less gasoline than the geologically more recent oil of the Bradford sand of Pennsylvania.

Differences in the catalytic activity of different formations of minerals in contact with crude oil may also account for the very puzzling fact that crude oils considerably different in composition are sometimes found separated vertically by only one or two hundred feet without any unconformity between the two producing formations. In such cases, the two oils must be of substantially the same geologic age and must have been subjected to substantially the same temperatures and pressures throughout their history. Smith and his associates suggested that such differences in crude composition may have been due to differences in the original environment of the source material or differences in the chemical composition of the original source material. There seems to be no tangible evidence for such assumed original differences but the observed facts may very plausibly be due to differences in the catalytic activity of the strata with which the oil has been in contact.

In the much folded, faulted and metamorphosed Rocky Mountain area the regularities in oil composition shown in the Gulf Coast fields is not shown. Dobbin (8) states that the quality of the oils in the Rocky Mountain area bear no demonstrable relation to the dynamic metamorphism which the region has under gone and notes, "It is evident, therefore, that in addition to metamorphism, there are other factors responsible for the quality of the oil, such as differences in origin—and *natural processes of refining or filtration.*"

FORMATION OF AROMATIC HYDROCARBONS

The apparently universal occurrence of aromatic hydrocarbons in petroleums, isolated and identified in straight-run gasolines, presents special difficulties. The proportions of aromatic hydrocarbons in various gasolines is given in the foregoing tables. In a few gasolines, such as that from Conroe, Texas, and certain of the Borneo crudes, the per cent of aromatics is very large. No type of abundant and widely-occurring possible source material contains aromatic groups sufficient to account for the presence of the aromatic hydrocarbons by any processes of simple degradation. Lignin and humic acids are the only natural materials occurring in abundance in nature which contain the benzene nucleus in its complex structure but they are almost certainly absent from the organic matter in marine deposits. They probably contribute to the formation of coal but not petroleum. The formation of aromatic hydrocarbons from paraffins has been treated from the thermodynamic standpoint by A. W. Francis (11) who states that temperatures in the range 550–900° C. are required, assuming the splitting off of hydrogen. According to Francis, the reactions possible below 550° C. are different in kind, so that at the lower temperatures the formation of aromatics from paraffins could not be expected even during geologic time. Experimental work bears out Francis' conclusions very well, so far as paraffins are concerned, although his temperature of 550° C. may be about 50° C. too high. The conclusions of Francis are very well confirmed by Taylor and Turkevich. (27)

There is a very extensive literature on catalytic dehydrogenation and the dehydrogenation of cyclohexane and its derivatives to benzene and its derivaties is a reversible process. The lower temperatures, in the presence of hydrogen, favor the conversion of benzenes to cyclohexanes, this reaction proceeding well experimentally at temperatures as low as 80°–100° C. with active catalysts. The dehydrogenation of cyclohexene to benzene in the presence of catalysts becomes noticeable experimentally at 170° C. Perhaps more significant is the fact that cyclohexene in the presence of certain catalysts undergoes hydrogen disproportionation being rapidly converted to benzene and cyclehexane, and pinenes are converted by Fuller's earth to cymene and para menthane, probably through the intermediate formation of terpinene, with evolution of considerable heat. The action of clays in causing such disproportionation reactions has also been mentioned by A. V. Frost, (12) in Russia, who also has suggested recently that clays have a role in petroleum formation. According to Herington and Rideal, (14) the formation of aromatics from paraffins in the presence of a chromium oxide on alumina catalyst at 475° C., proceeds through the formation of a mono-olefin. Nenitzescu, (17) who also urges the study of geologically recent bituminous deposits as possible intermediates in petroleum formation, concludes that aromatic hydrocarbons are formed "at some low temperature" by an unknown process.

OTHER RECENT THEORIES

Brief mention should be made of recent researches seeking to explain pteroleum origin by bacterial action and by the effect of alpha radiation from radioactive minerals upon methane or upon the original organic source material of petroleum.

With respect to bacterial action, it is well known that methane is formed by bacterial action on cellulose. However, the formation of hydrocarbons, other than methane, in this way has never been observed and this appears to be a specific bacterial degradation of cellulose. Methane in relatively small amounts is frequently observed in coal deposits, but in such cases is not accompanied by the series of methane homologs found together with methane in natural gas. These two occurrences of methane appear to be entirely unrelated.

Loss of CO_2 from fatty acids has been observed in anaerobic fermentations and the destruction of petroleum oils by bacterial action (30) under *aerobic* conditions, probably by oxidation, has been reported by several observers.

NATURAL GAS AND THE RADIOACTIVITY THEORY OF PETROLEUM ORIGIN

S. C. Lind (15) has shown that the action of alpha radiation from radioactive material on gaseous hydrocarbons results in the splitting off of hydrogen and the formation of a complex mixture of liquid hydrocarbons. He mentions that rocks of the earth's crust are universally radioactive, although in very low intensity. The oily products formed under such circumstances are highly unsaturated. Lind considered this an objection to such a theory of petroleum origin. The unsaturated hydrocarbons could be polymerized, but the disappearance of hydrogen would be more difficult to account for In any case, the non-reactive by-product helium should persist Helium rarely occurs in natural gas and its occurrence, from about 0.5 to 2.0 per cent in some of the natural gases in northern Texas, western Kansas and Oklahoma, is to be explained by the proximity of old buried granite ridges and the Shinerump conglomerate of Colorado, which contains carnotite. (4) The gases richest in helium contain no hydrogen. In a private communication Lind states that he is unable to see any solution of the hydrogen and helium difficulty.

To assume that hydrocarbon gases, or methane, is the parent substance of petroleum would still leave unanswered the origin of the methane. Sheppard and Whitehead, (24) on the other hand, query the action of alpha radiation on the buried organic matter in the sediments. Their very painstaking and careful work shows that CO_2 is split out of fatty acids.

There can be no doubt, of course, of the experimental results. However, the principal objections to the theory that petroleums have been formed from either methane or buried organic matter in the sediments by radioactivity are probably as follows: (a) the composition of natural gas, the complete absence of hydrogen and only the occasional presence of helium; (b) there is no relation between the abundance of petroleum and natural gas and the proximity of radio-active minerals (intensity of alpha radiation); (c) the absence of olefinic unsaturated hydrocarbons in gases of petroleums. If the process is as stated to be, dependent upon the widespread radioactivity of low intensity, then the process must be a continuing one and unsaturated hydrocarbons and hydrogen would be expected. The most serious discrepancy between the observed facts and the alpharadiation theory is that the outstanding experimental result of the action of alpha radiation on hydrocarbons is that it knocks off hydrogen atoms. Such continued action would produce progressively heavier oils poorer in hydrogen. This is quite contrary to the *observed facts with respect to the geologically old, light paraffinic crudes* (d) Optically active hydrocarbons in petroleum could not be expected, but petroleums do contain slightly optically active hydrocarbons. (e) Substance found in petroleums and derived from organic matter buried in the sediments, such as chlorophyll porphyrins, naphthenic acid complexes, nitrogen bases and labile sulfur complexes, must either escape destruction by alpha radiation or these substances must be picked up subsequently by the oil, possibly during migration. In 1944 Sheppard concluded, "In this survey of the origin of petroleum from the physicist's point of of view, no conclusions can be drawn as to whether or not radioactive processes are significant in petroleum genesis."

In this connection it should be noted that marine sahles, rich in kerogen, show exceptionally high radioactivity, but as already noted, such shales may be geologically very old, rich in organic material and contain little or no oil as such.

Finally, when oil (or gas) does come into contact with radioactive minerals extensive decomposition with carbon formation occurs as is shown by the mineral thucolite. In Canadian pegmatites, near Parry Sound, Ontario, and near Buckingham, Quebec, the mineral thucolite occurs, sometimes as a pseudomorph after uraninite. Analyses showed the mineral to contain 50.8 to 61.5 per cent carbon, about 2 per cent moisture, 20 per cent volatile hydrocarbons (gases) and 16.6 to 26.8 per cent ash consisting largely of uranium and thorium oxides. (26) Crevices and cracks in the adjacent pegmatite rock contained an oil substance which apparently had seeped into the pegmatite from the country rock subsequent to the intrusion of the pegmatite. Thus the action of the radioactive material on the oil was apparently extremely local and resulted in the formation of carbon and gases, a result to be expected from the experimental results showing splitting off of hydrogen.

SUMMARY

(1) A relatively low temperature history, through geologic time to the present, is indicated by the presence in petroleum of thermo-labile types of substances and by geological considerations. Temperatures within the range of 100° to about 250° F. have probably been the rule for most petroleum-bearing strata and source beds.

(2) The presence of chlorophyll porphyrins is also evidence of low temperature history, but this fact also shows that the material containing chlorophyll, probably marine algae or kelps, was deposited and preserved from aerobic bacterial action by rapid sedimentation. Petroleums containing porphyrins were probably derived from deposited organic material associated with green algae or kelps. Rapid sedimentation in relatively shallow, subsiding basins is also indicated by geological evidence.

(3) The chemical complexity of petroleums, together with the evidences of low temperature history, are best accounted for by *catalytic activity of active surface minerals*, particularly clays, with which oil has been in contact for long periods of time. Petroleums are not equilibrium mixtures produced by thermal action alone. The time element and evident geological history precludes oil or its source material ever having been heated to temperatures as high as 400° C.

(4) There is much evidence that low intensity radioactivity has had nothing to do with the origin of petroleum.

(5) Formation of hydrocarbons, other than methane by bacterial action, has not been demonstrated. Bacterial action undoubtedly occurred in the fresh sediments, as laid down, but later action to form hydrocarbons, is highly specu-

lative. Bacterial action cannot reasonably explain the complexity of petroleums as to number and types of hydrocarbons found in petroleums.

(6) Differences in original organic source material may explain the formation of coal, kerogen of shales and petroleums, including natural gas, as final end products. Such possible differences may account for some of the differences in petroleums, but cannot possibly account for the number and types of hydrocarbons found in typical petroleums.

(7) Fatty oils appear to be the most likely source material of petroleums, with proteins and cellulose probably also contributing.

(8) We lack chemical knowledge of the organic matter deposited in contemporary and recent sediments. Chemical investigation of organic matter in geologically recent strata should provide a chemical history of petroleum formation in intermediate transition stages.

(9) The formation of petroleum appears to have taken place in two general stages; first, an early stage, in which organic matter buried in marine sediments is chemically changed to material consisting largely of carbon and hydrogen but containing few hydrocarbons; second, a later stage in which a very large number of paraffins, isoparaffins, naphthenes and aromatics were formed by catalytic action of active surface minerals, including clays, at relatively low temperatures.

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THE BEDROCK SURFACE AND FORMER DRAINAGE SYSTEMS OF MONTGOMERY COUNTY, OHIO[1]

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INTRODUCTION

The bedrock surface of Montgomery County, Ohio (in which Dayton is situated), has been contoured in considerable detail. Elevations at more than 500 points on the bedrock surface were obtained in the course of a well survey conducted by the Ohio Water Resources Board and the U. S. Geological Survey in the summer of 1946. This survey was made to obtain data for a report on the water resources of the county, which is to be published in 1948 by the Ohio Water Resources Board.[2]

The bedrock underlying the glacial drift of Montgomery County consists of interbedded shales and limestones of Upper Ordovician age, capped over large areas by Middle Silurian limestones and dolomites. The rocks of both systems are so resistant that the casing in drilled water wells ordinarily can be driven only to the top of the bedrock surface. In wells that are drilled into the rock, therefore, the length of casing generally can be taken as the depth to the rock surface. In wells where the length of casing is the same as the total depth of the well it may be assumed that the well was finished in unconsolidated formations, bedrock not having been penetrated. In the field survey of wells these assumptions were used as a basis for acquiring the data for the bedrock contour map. The length of casing in wells was determined by means of an electrical device invented by the author and submitted for patent by the U. S. Department of Justice. The elevation of the rock surface was computed by subtracting the length of casing from the elevation of the land surface at the well, as shown by the topographic maps of the U. S. Geological Survey.

Montgomery County comprises parts of four quadrangles, namely, the Brookville, Dayton, Miamisburg, and Waynesville quadrangles. These quadrangle maps were used as a base on which to contour the bedrock surface. The accompanying plate is a reduced tracing of the bedrock contours developed on this base map. A full-scale copy of this bedrock contour map, showing 50-foot contour intervals, is to be included in Bulletin 12 of the Ohio Water Resources Board.

PREGLACIAL TOPOGRAPHY OF MONTGOMERY COUNTY

Before Pleistocene glaciation Montgomery County probably resembled the part of the Bluegrass region of Kentucky that lies just south of the glacial border. The topography of both areas is of similar origin with respect to the structure and stratigraphy of the underlying rocks. They are areas of regional uplift in which rocks of Upper Ordovician age, with a border of Silurian limestones, are exposed at the surface. The present Bluegrass area consists of a fairly smooth, gently rolling surface deeply dissected by short tributaries and broad, entrenched rivers, similar to the bedrock topography of Montgomery County. The covering of glacial drift over Montgomery County has subdued its former relief and masked all but the most prominent features of the ancient drainage.

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[1] Presented at the meeting of the Ohio Academy of Science, Toledo, Ohio, on May 7, 1948. Published by permission of the Director of the U. S. Geological Survey.

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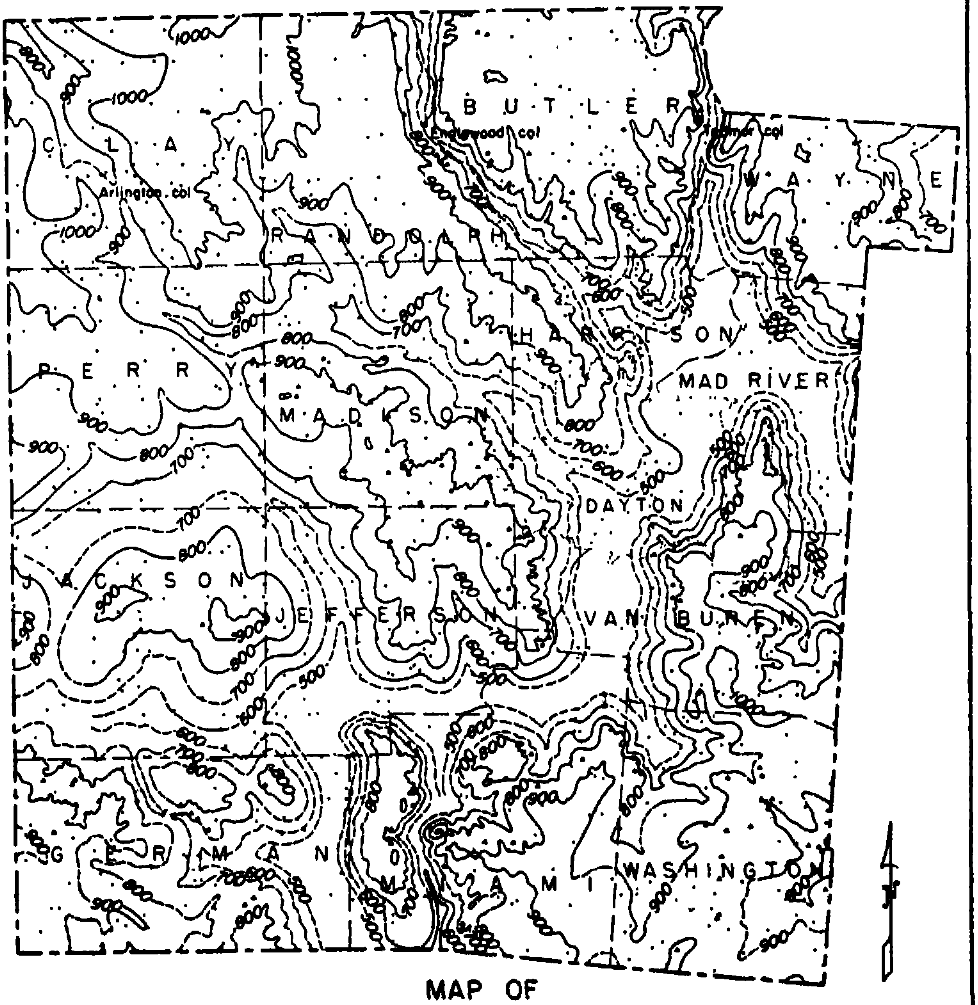

MAP OF
MONTGOMERY COUNTY, OHIO
SHOWING CONTOURS ON BEDROCK SURFACE

CONTOUR INTERVAL 100 FEET
ELEVATIONS GIVEN IN FEET ABOVE SEA LEVEL

SCALE IN MILES
0 1 2 3 4 5 6

EXPLANATION:
- • LOCATION OF WELL DATA
- • BEDROCK OUTCROP

GEOLOGY BY S.E. NORRIS

JR

PREGLACIAL (TEAYS STAGE) DRAINAGE IN MONTGOMERY COUNTY

The earliest recognizable drainage system in Ohio is called the Teays system and all streams in existence at that time are referred to as "Teays Stage" drainage.[3] The Teays system, it is thought, antedated the earliest of the glacial stages of the Pleistocene epoch. The master Teays River rose in the Piedmont area in the southeastern part of the United States and flowed across Ohio in a northwesterly direction in a course that lay a few miles north of Montgomery County. The Teays drainage system must have endured for a considerable length of time, for the streams eroded broad, deep channels and developed an immature peneplain or base level known as the Parker Strath.

Montgomery County, because of a drainage divide in its northern part, was drained only partially by the main Teays River. The greater part of the county was drained by a large Teays tributary named by Stout [4] the Hamilton River. The Hamilton River flowed southward through Montgomery, Butler, and Hamilton Counties, then turned westward and entered the Teays River somewhere in Indiana.

The former course of the Hamilton River through Montgomery County is defined by the bedrock contours shown on the accompanying plate. In Teays time it entered Montgomery County from the east near the boundary line between Mad River and Van Buren Townships. From this point the Hamilton flowed northwestward to about the Middle of Mad River Township and from there it flowed westward to Dayton, cutting that part of its valley now occupied by the Mad River. At the site of Dayton the Hamilton River received from the north and northwest the waters of three large tributaries whose courses are now occupied by the Miami River, which flows in part along the western border of Wayne Township; the Stillwater River, whose present course is in part along the western border of Butler Township; and Wolf Creek, which flows through Madison Township. In Teays time these tributaries terminated in the uplands of Montgomery County in col areas respectively at Tadmor, Englewood, and Arlington. The valleys on the northern sides of these cols were cut by north-flowing tributaries of the main Teays River.

From Dayton to the southeastern corner of Jefferson Township the Hamilton River cut a broad course that is now occupied by the Miami River. The course of the Hamilton from that point was westward through the southern part of Jefferson Township, and thence southward through the eastern part of German Township to the county line. In the southwestern part of Jefferson Township the Hamilton was joined by two large tributaries, both of which entered Montgomery County from the west.

A col or drainage divide existed in Miami Township in Teays time, at the site of the city of Miamisburg. This col separated two short opposite-flowing Hamilton tributaries. Two other cols existed in north-central German township.

The width of the Hamilton River valley in Montgomery County, as shown by the map contours, averaged more than 1 mile at river level and up to 3 miles at the divide levels. In Teays time the main stream was entrenched some 200 feet below divide levels.

In Montgomery County streams of later drainage stages greatly deepened the valleys originally developed in Teays time and only a few scattered remnants of the Teays valley levels are now to be found. These remnants of the Teays valley floor occur as terraces along the sides of some of the more recent valleys at elevations ranging from 750 to 770 feet for former tributaries in the northern part of the county, to elevations as low as 650 feet along the main stream in the southern part of the county. Not enough well records are available to determine the gradient of the floor of the main Teays-stage Hamilton valley.

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[3] Stout, Wilber, Ver Steeg, Karl, and Lamb, G. F., Geology of Water in Ohio: The Ohio Geological Survey Bull. 44, 4th Ser., 1943.

[4] Stout, Wilber, Ver Steeg, Karl, and Lamb, G. F., *op. cit.*

The existence of the Teays drainage system, according to Stout and others,[6] was terminated by the advance to the central Ohio area of a very early pre-Illinoian glacier, perhaps of the Kansan stage. This early glacier, it is thought, did not reach the area of Montgomery County, but it did advance to a point where it blocked the main Teays River to the north. This caused major diversions of the drainage lines and inaugurated the succeeding "Deep Stage" drainage system. The Deep Stage system is so called because during this time the streams cut deep, narrow valleys many feet below the levels established in Teays time. This down cutting might have resulted in part from regional uplift of the land surface shortly after the start of the Deep Stage drainage cycle.

DEEP STAGE DRAINAGE IN MONTGOMERY COUNTY

It seems evident that the Hamilton River in Deep Stage time persisted in its original course in Montgomery County, as did its principal tributaries. Well records at several points in the Hamilton valley in Montgomery County show no evidence of lake deposits, indicating that the south-flowing Hamilton River probably was not ponded by the pre-Illinoian glacier, as were parts of the main Teays system. The cols at Tadmor, Englewood, and Arlington might have been cut through in Deep Stage time with the extension northward of three Hamilton tributary valleys. The reduction of these cols, if it happened in early Deep Stage time, might have resulted from the overflow of waters from ponded Teays valleys to the north. Available well records in the valleys north of these cols in Montgomery County show a considerable thickness of very fine sand, but no silts or lake clay deposists. Apparently, if ponding did occur, any lake deposits in these valleys must have been of small extent or were removed by later streams before the glaciers deposited their materials.

Deep Stage valleys in Montgomery County are comparatively wide, perhaps as much as a mile in the Hamilton valley. The lowest elevation of the valley floor recorded at Dayton is about 513 feet above sea level, nearly 200 feet lower than the Teays level. A test well in southeastern Jefferson Township, and thought to be near the axis of the Deep Stage channel, struck bedrock at the depth of 212 feet, or at an elevation of about 500 feet above sea level. If this point and the one at Dayton are in the deepest parts of the valley, a gradient of about 1 foot per mile is indicated for the main Hamilton valley in Deep Stage time, which is probably too low.

EFFECTS OF GLACIATION ON THE DRAINAGE IN MONTGOMERY COUNTY

The Illinoian glacier, the first ice sheet to cover Montgomery County, ended the Deep Stage drainage cycle and began a new drainage system which was probably much like the present system as it has evolved since the more recent Wisconsin glaciation.

It is probable that the Illinoian glacier caused a minor drainage diversion in the west-central part of Miami Township, where it forced the main Hamilton drainage through a narrow col which in Teays and Deep Stage times had separated two short tributaries. Drainage diversions were likewise caused in German Township where two smaller cols were breached by ice-diverted drainage or by melt water from the glacier. It is also possible that the cols at Tadmor, Englewood, and Arlington were cut through in this way.

The work done by the post-Illinoian streams consisted mainly of the removal of part, and in some areas probably most, of the valley deposits laid down by the

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[6] Stout, Wilber, Ver Steeg, Karl, and Lamb, G. F., *op. cit.*

Illinoian glacier. The post-Illinoian interglacial period was brought to a close by the advance of the Wisconsin glacier, the latest ice sheet to cover this area.

The Wisconsin glacier probably caused some changes in the drainage lines of post-Illinoian time in Montgomery County. Perhaps the Wisconsin ice caused some of the changes in the Deep Stage system that are credited herein to the Illinoian glacier. It is believed, however, that the main effect of the Wisconsin ice sheet on the former drainage was in supplying the greater part of the unconsolidated materials that now fill these valleys.

It is planned by the Ohio Water Resources Board and the U. S. Geological Survey to extend a well survey, such as the one completed in Montgomery County, into the adjacent counties of Greene, Clark, Miami, and Champaign. Detailed maps of the bedrock surface in these areas will undoubtedly help to define in detail the drainage history of the entire southwestern part of Ohio.

Genetics, Medicine, and Man

This book contains the text of six Messenger Lectures, two by each of three eminent geneticists, talking from his own research experience on the given tripartite subject. Dr. Muller presents the fundamentals of genetics with simple language in a manner that provides a refreshing review, especially for anyone whose only previous contact with genetics has been by way of the complexities of an elementary text book course. The effects of the mechanism of sexual reproduction on evolution are discussed in relation to directing them toward long term human welfare.

Dr. Little defines genetics as "the science of studying parental influence upon offspring." He takes a broad view to the extent of including items which orthodox geneticists would classify as purely environmental (non-generic) influences. For convenience, he distinguishes three overlapping categories of influence: morphogenetic, endocrine-emotional, and psycho-social. The simple points which he makes in plodding complicated style are: that every gene is always in some kind of an environment, and, that such things as physiological reactions, emotional stability, and social behavior are affected by genes as well as by environment. The advantages of seeking knowledge of man indirectly through a study of laboratory mammals over studying humanity directly are emphasized.

Dr. Snyder's fine style provides a satisfying finale for the book. It deals with the segment of the theme which will be of most interest to non-geneticists. He points out the direct, practical applications of genetics to man that are already being made. A discussion of some of the special problems which the study of human heredity presents and examples of some methods through which they are being outmaneuvered are explained. Genetic maps of human chromosomes are illustrated.—*Elton F. Paddock.*

Genetics, Medicine, and Man, by H. J. Muller, C. C. Little, and L. H. Snyder. 158 pp. Ithaca, New York, Cornell University Press, 1947. $2.25.

SOME WILDLIFE AND LAND USE RELATIONSHIPS IN OHIO

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Although the first white people who came into the Ohio Territory as hunters and trappers probably gave little or no thought to conserving, propagating or managing wild animals, it was relatively early in Ohio's history when laws were first passed to protect economically important animals. As indicated in a companion paper by Dambach to be published in a later issue of this Journal, a law was passed in 1829 to protect the valuable fur-bearing muskrat during its reproductive season. This was followed in succeeding years by other protective or restrictive legislation establishing seasons and daily bag limits according to game abundance and regulating the manner in which animals could be killed legally.

Protective legislation is only one of several methods man has used to manage wildlife species. Artificial propagation of game and fish, followed by stocking has been and still is popular with Ohio sportsmen, although numerous studies have shown that game farm birds and hatchery fish supply only a fraction of the annual harvest. Refuges have been established to provide sanctuary to game animals during and following the hunting season so that ample brood stock might remain for the following year. Such areas have been of particular value to the ring-necked pheasant and waterfowl. Granted that refuges, restocking and protective legislation play their part in wildlife management, it is apparent that in the present plight of our pheasants, our waterfowl and our Hungarian partridges, these measures have not been entirely successful.

One of the most promising management techniques is that of habitat improvement. This method is based on the hypothesis that when the environmental requirements for a given animal are satisfied it will be able to approach its biotic potential and be present in goodly numbers; conversely, if the habitat is not satisfactory, no amount of stocking or protection will result in sustained high populations of the animal. Obviously, exotic species such as our ring-necked pheasant and Hungarian partridge would not be in Ohio today if the habitat had not been suitable for their existence when they were stocked.

The Ohio Division of Conservation and Natural Resources in recognition of the necessity of providing suitable wildlife habitat, initiated a program of habitat improvement throughout Ohio in 1947. It is the purpose of this paper to indicate important wildlife-land use relationships which are involved in the development of a wildlife management program in Ohio.

WILDLIFE DURING OHIO PIONEER DAYS

Although frequent accounts were written by the early Ohio settlers concerning some of the more conspicuous animals inhabitating the area, little accurate information was recorded concerning the smaller and often more inconspicuous birds and mammals. Even today when much attention is given to the censusing of wild animals we still have but little accurate information on wildlife populations.

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[2] The Ohio State University, the Ohio Division of Conservation and Natural Resources, the U. S. Fish and Wildlife Service and the Wildlife Management Institute cooperating.

We know that Ohio was originally a forested area (± 95 per cent) with a relatively small amount of prairie and marsh land. We know that several mammals once present in Ohio, including the fisher, timber wolf, wildcat, porcupine, snowshoe rabbit, American elk, bison, panther and marten, were extirpated because of habitat destruction, hunting or for other reasons. We also know that many birds that once occurred in Ohio are no longer present. These include the wild turkey, greater prairie chicken, raven, whooping crane and swallow-tailed kite, which although extirpated from Ohio are still found in parts of the United States; and the passenger pigeon, Louisiana paroquet and the Eskimo curlew, which are not extinct.

The American Indians, who lived in, or visited the Ohio territory before the white man came, were hunters and small scale farmers. They are said to have occasionally burned off small areas and raised some corn, beans and pumpkins. Their inroads on wildlife were of much importance to their own welfare but probably had little effect on the fish and game populations.

With the coming of the White man to the Ohio territory, habitat conditions then existing were altered. The early settlers reached considerable numbers first along the Ohio River and its tributaries and along the southern shore of Lake Erie. In 1800 there were only 45,000 white men in the territory. The Indians were forced out of the state about 1845. By 1850 most of the counties in the eastern half of the state had reached their maximum rural population (Beck 1934). Settlement was practically complete by 1880 except for a few areas, most of which were in the poorly drained Maumee plain of northwestern Ohio. It was here that many of the larger forest species were last reported in Ohio. In 1840 agriculture was still the chief industry, but by 1930 Ohio had become an industrial state with less than one-sixth of its population living on farms (Beck *op. cit.*).

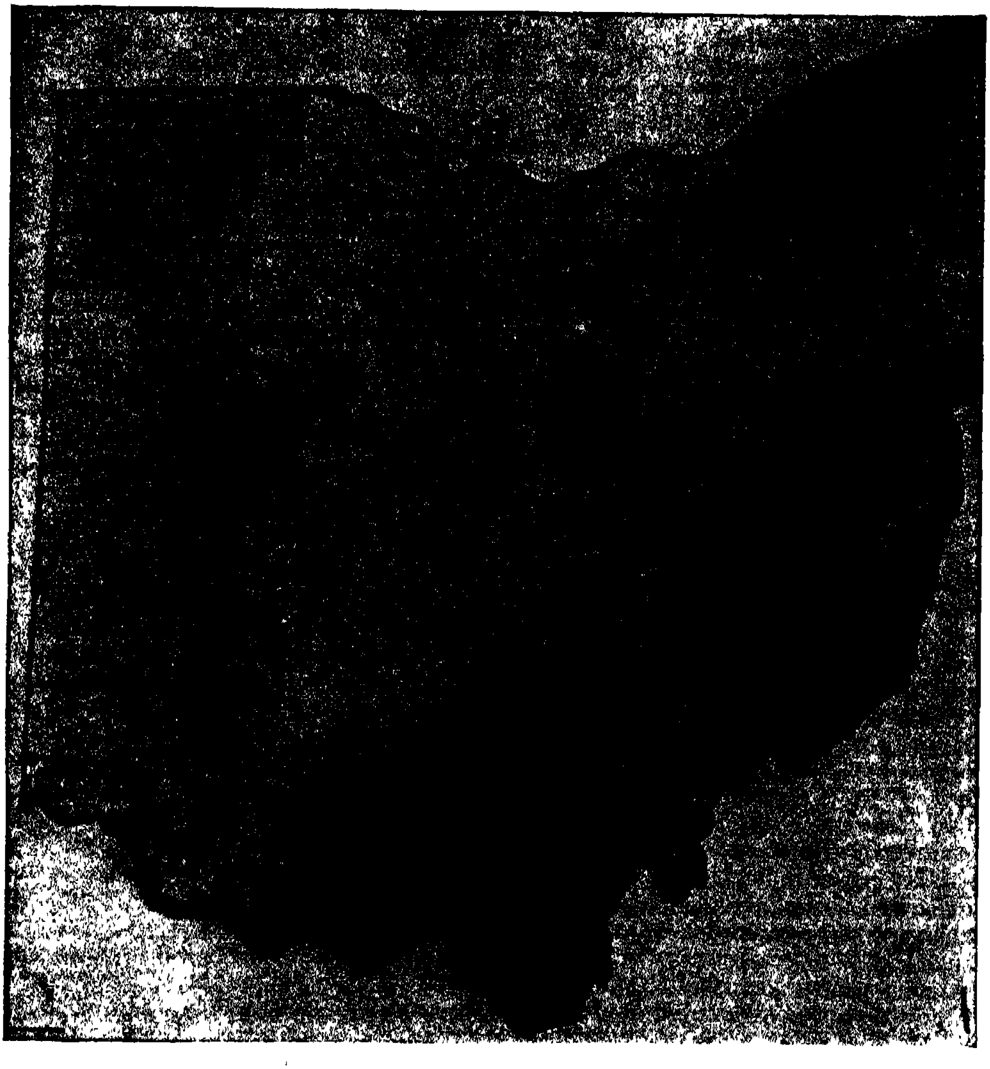
The most marked ecological change produced by the settlement of Ohio came as a result of the clearing away of the forests which began in the southeastern counties about 1788. The land was cleared not only for agriculture, but also in the interest of mining, salt and steel industries, which required large supplies of wood for mine props, fuel and charcoal. By 1890 forest clearing in Ohio was nearly complete, the rural population had reached a maximum and some of the earliest cleared land in southeastern Ohio was already being abandoned. (Sitterley and Falconer, 1938).

SOME HABITAT CHANGES RESULTING FROM THE SETTLEMENT AND DEVELOPMENT OF OHIO

Disappearance of forest cover and the plowing of the virgin soil (all too frequently up and down the slopes) accelerated erosion. The streams became silt laden and flooding was possibly more frequent and extensive. By the mid-1930's about 32 per cent of the state was affected by moderate sheet erosion and 16 per cent, mostly in east central and southeastern Ohio, was severely eroded. (Conrey, Cutler and Paschall, 1937).

Clearings made by the first pioneers were only small openings in the forest. In the more rugged sections of southern and eastern Ohio the remaining wooded areas later assumed a dendritic pattern, following streams, steep-sloped ravines and rough terrain. Forest edge thus provided was especially valuable for such species as the bob-white quail. In the more level areas of north-central and northwestern Ohio, 80 to 90 per cent of the woods were eventually removed leaving scattered, rectangular woodlots separated by much larger blocks of open farm lands with a few connecting arms or brushy fencerows to be used as travel lanes by wild animals.

In addition to the cutting of the forests, the draining of sizeable swamp and marsh lands in northern Ohio greatly altered the wildlife habitat and converted the former into some of the richest agricultural land of the state. In Wood County alone there are now more than 2,000 miles of open drainage ditches. These ditches provide travel lanes, cover and food for many animals including muskrats, which feed on the crops (corn, soybeans, alfalfa, etc.) now grown in adjacent fields.



Forest cover of Ohio. "Prepared by Forest Survey, Ohio Agricultural Experiment Station, Wooster, in cooperation with Central States Forest Experiment Station, Columbus. Map compiled from aerial photographs provided by Agricultural Adjustment Administration. Black areas indicate woodlands." (See Ohio's Forest Resources, Forestry Publication No. 76. Ohio Agr. Expt. Sta. and Central States Forest Expt. Sta.)

With the rapid growth of cities and industrial plants in Ohio, wastes, both human and industrial, were poured into Ohio streams, often affecting fish and other aquatic life adversely. Mr. E. L. Wickliff, Chief of the Fish Management Section of the Ohio Division of Conservation and Natural Resources, in conversation January 25, 1948, stated that fish may be exterminated locally as a result of habitat changes but few have been completely extirpated from Ohio and a few have been introduced by man.

The streams (some 12,000 miles of them) which flowed through Ohio's virgin forests were probably cooler and clearer than those now present. They probably had frequent pools and eddies due to trees falling across them, and they also probably had an bundant food supply for fish. The silt and mud found in our streams are there today because of erosion. The suspended silt particles tend to absorb more of the sun's rays, thus making the water warmer, and through reduced photosynthesis, decrease the amount of aquatic vegetation and other organisms available for fish food. Langlois (1941) pointed out these and other relationships obtaining in the southwestern part of Lake Erie and indicated the adverse effect silt had on ciscoes, whitefishes and yellow perch.

Originally there were only ten to twelve square miles of impounded water (lakes) in the Ohio area. Today there are more than 100 square miles of such water with many farm ponds and lakes under construction and others projected for future building. Thus the habitat for such species as the white crappie, blue gill, largemouth bass, channel catfish, bullhead catfish, pumpkinseed, black crappie and yellow perch has been greatly increased.

SOME CHANGES IN OHIO FAUNA RESULTING FROM HABITAT ALTERATIONS

We have seen that Ohio was changed, through settlement, from what was once primarily a deciduous forest environment, to an agricultural land with prairie-like characteristics. Many typically forest animals were extirpated while other animals, more adapted to the new environment, moved into Ohio or increased in numbers after the country was settled. Among the mammals which are more abundant in Ohio than originally are the thirteen-lined ground squirrel or spermophile, prairie white-footed mouse, meadow mouse or vole, badger, and the introduced Norway rat and house mouse. The cottontail rabbit, skunk, opossum, muskrat, fox squirrel and prairie mole are also probably much more common now than formerly. There is apparently some question about the occurrence of the red fox in the Ohio area before the White man came. If it did occur originally, it was less abundant than at present.

The vesper, field, Savannah, grasshopper and Henslow's sparrows, and the dickcissel, bobolink and prairie horned lark have evidently benefited from the changed Ohio environment and are more abundant than formerly. Other birds such as the robin, housewren, nighthawk and the introduced English sparrow and starling became adapted to man's settlements and greatly increased in numbers. The red-winged blackbird now frequently nests in alfalfa and red clover fields, cover types which were not available in the Ohio wilderness area. Among the more southern species which have extended their ranges northward are the Carolina wren, cardinal, tufted titmouse, mockingbird and chuck-will's widow

Such fishes as the bluegill, crappie and large-mouthed bass which are adapted to living in lakes and ponds are much more abundant than originally due to the increased habitat resulting from man's pond and lake building activities. Some changes in fish distribution have also taken place. Mr. E. L. Wickliff reports that the sucker-mouth minnow apparently invaded Ohio from the west and is adapting itself to the streams of central and eastern Ohio. Also with the building of Ohio canals the white crappie moved northward in the state.

In general what has been said about the changes occurring in the population of mammals, birds and fish probably also applies to insects and other forms of life, namely, forest species have decreased in numbers, whereas prairie species such as many of the leafhoppers, grasshoppers and plant bugs have increased. Although many of the economically important insects are exotics, having been accidentally introduced here by man, the chinch bug is a native species that originally lived in the corn belt area where it infested prairie grasses such as *Andropogon* sp. Man plowed up this area and planted the cultivated grasses, wheat and corn. The chinch bug became adapted to the new conditions and now attacks both plants.

This brief summary of changes brought about by civilization indicates some of the general relationships existing between man and wildlife. It indicates how man can drive out animals by destroying or altering habitat and how, often unwittingly, he can create new habitat conditions which will enable other animals to live and multiply in number.

Although Ohio's wildlife belongs to the people of the state, the bulk of the wildlife (probably more than 90 per cent) is produced, as an unplanned crop, on privately-owned lands. It is obvious that the landowner is in a key position to manage wildlife, and the State, which owns only a small percentage of the land in Ohio, must either devote its efforts to managing this small publicly owned area or to working through the landowner in any program which involves extensive wildlife habitat development. The landowner has but little incentive to produce more game on his land under present day conditions when, in most instances, he receives no remuneration from the hunters and when, as he realizes, the more game he has on his property the more people he will have hunting or asking to hunt on his land. The farmer knows also that many, though not all, of the wildlife management measures he can practice, take land out of crop production and thus cost him money. The owners of some waterfowl and muskrat marshes have learned that they can manage the marshes for profit. They harvest the muskrats and charge fees for waterfowl hunting privileges. Fortunately for the "one-gallus hunter", most landowners are quite willing to permit upland game hunters on their property as guests as long as they respect the property and behave as true sportsmen.

In developing a program of game management in Ohio the land use—wildlife relationships mentioned below should be recognized. Obviously, since game is a secondary crop in Ohio, most of the agricultural practices affecting wildlife will be altered for the benefit of wildlife only insofar as the landowners are assisted in their game management efforts or are shown that certain management measures are beneficial to their interests.

1. *Cultivated crops as wildlife food*

Yellow corn is probably the most important wildlife food in Ohio, being consumed by pheasants, squirrels, raccoon, muskrats, deer and many other animals. Of great importance also are wheat and soybeans. The production of these crops has increased during recent years in much of Ohio. In six pheasant belt counties, for example, the acreage devoted to soybeans was increased 78.9 per cent from 1940 to 1945, while corn and wheat acreages were increased 5.0 and 15.6 per cent respectively (Ray et al., 1943, 1946). Smartweed, lesser ragweed and fox-tail grasses commonly associated with these crops are also excellent wildlife foods and increase in abundance as the acreages in row crops increase. Extensive use of herbicides such as 2, 4-D may, however, materially reduce this source of food and cover in the future.

2. *Harvesting methods as they affect the availability of cultivated crops for wildlife foods*

Mechanical corn picking is rapidly taking the place of the cutting and husking method of corn harvesting. Field observations in a large part of the pheasant belt of western and northwestern Ohio indicated that only about 10 per cent of the corn was picked in 1936 compared to 70 per cent in 1946. Since most of the picked corn is now harvested by machine instead of by hand, and since mechanical pickers leave more waste grain in the fields than the other methods, the increased use of machine pickers has resulted in an increased amount of waste corn, available except under ice and deep snow, as wildlife food.

Soybeans, when grown for hay, pasture or green manure, are of relatively little direct value to wildlife but when combined for grain the waste beans are utilized by pheasants, rabbits and other animals as food. According to Ray *et. al.*, (1943) the percentage of soybeans in Ohio which was harvested for grain increased from 49.1 in 1936 to 73.0 in 1941. The author (Leedy 1939) found by sampling fields in Wood County, Ohio, an average of approximately 292 pounds of corn left per acre in machine-picked corn fields and 227 pounds of soybeans per acre in combined soybeans. He also found smartweed seed produced at an average rate of more than 47 pounds per acre in corn and soybean fields sampled and ragweed seed at a rate of approximately 86 pounds per acre in unclipped wheat stubble. It is thus apparent that much food in the form of waste grain and weed seeds is available to wildlife in intensively farmed areas where the limiting factor is likely to be lack of adequate wildlife cover.

3. *Agricultural Crops as Wildlife Cover*

Since agricultural crops constitute the bulk of the cover now present in Ohio it is expected that they should be used as such by wild animals. Such cover is at a maximum during midsummer but is gradually reduced by harvesting, stubble clipping and plowing so that only a relatively small amount is left by March. Wild animals shift from field to field until by spring they are often concentrated in a semi-permanent type of cover consisting of a few brushy fencerows, woodlots, ditch banks, and idle fields. Spring burning of ditch banks, fencerows, and roadsides reduces this cover still further.

During the years 1939 to 1941 nesting studies made in the Ohio pheasant belt by the Ohio Wildlife Research Unit indicated that approximately two-thirds of the pheasants nested in hay meadows. Many rabbits also have their nests in meadows. According to Ohio Agricultural Statistics (Ray el al., 1946) there was a reduction of 24.4 per cent in hay acreage in six Ohio pheasant counties from 1940 to 1945. This trend has probably been detrimental to pheasants and other birds such as the red-winged blackbird, sparrows, dickcissel, and meadowlark which nest in meadows. For example, studies made in southwestern Ohio (Dambach and Good, 1940) indicated about 50 pairs of breeding birds per 100 acres of meadow compared to an average of ten pairs per 100 acres of small grains.

Unclipped wheat stubble left by combines provides excellent roosting sites for pheasants throughout the fall and even during the winter and early spring months. Standing corn also provides superior cover; it is frequented by pheasants, rabbits, bob-white quail and other animals. Although machine pickers break over the corn stalks, more cover is left in the fields than when the corn is cut and husked or put into silos.

4. *Ohio woodlots and forest areas in relation to wildlife*

Although woodlots and forests now constitute only about 14 per cent of the total land area in Ohio (Pl. I) they provide the year around home for many animals and the part time home of several other animals. In the more heavily forested area of eastern Ohio white-tailed deer and beaver are reappearing and extending their range after having been extirpated. Based on the estimate of game protectors there was approximately 9,300 deer in Ohio, 1947 as compared with 4,400 reported in 1943, indicating an increase of 114 per cent in four years (Leedy, 1947). According to Sitterley (1944), during the first 40 years of the present century the number of farms in the southeastern third of Ohio dropped from 86,759 to 73,073 and the land in farms from 8,148,134 acres to 6,949,919 acres. The shift in land use from farms to woodland is apparently still in progress and there are approximately 1,500,000 acres of marginal or submarginal land best suited to be in forest, bringing the potential woodland area of Ohio to 5,207,598 acres or one acre in woods out of every five acres of land area (Diller, 1944). The retirement of farm units and the increased acreage of forest land are providing more habitat for grouse, gray squirrels, deer and beavers.

In the larger, glaciated section of Ohio most of the forest cover is in the form of isolated woodlots. In the western part of the state more than three-fourths of these woodlots are pastured. Woodlot pasture is inferior in quality and quantity to rotation pasture. The practice of woodland pasturing is not only detrimental to most forms of wildlife but reduces the production of other forest products including lumber, fire wood and maple syrup.

Dambach (1944) found, in comparing a grazed and an ungrazed woodlot in Geauga County, Ohio, that for a five-year period breeding birds in the ungrazed area were four times more abundant and represented twice as many species as those in the grazed woodlot. He estimated that there were 81 mammals per acre in the ungrazed as compared to 49 per acre in the grazed woodland at the end of a ten-year period. In Butler County in southwestern Ohio, Dambach and Good (1940) found approximately twice as many pairs of breeding birds in unpastured as compared with pastured woodlots.

The author, working in Wood County, Ohio, in 1937 recorded 19,891 pheasants of which 23.6 per cent were seen in woodlots. The woods were apparently of greatest value in the winter, when 37.3 per cent of all pheasants seen were in that type of cover, and least utilized in summer, when only 5.4 per cent were in woods. More than three-fourths (76.9 per cent) of the pheasants seen in woods were within 25 yards of the outside edges. Woodlots harboring the most pheasants were ungrazed, or if grazed, had patches of wild roses, brambles, prickly ash, *Crataegus* or other protective cover in them. In addition to providing cover of much value to pheasants in the winter and early spring, woodlots are also used for roosting sites and to some extent for feeding and nesting sites.

The fox squirrel, an animal of the prairie edge, is undoubtedly more abundant in Ohio now than under the original forested conditions. It is able to live in farm woodlots on hickory nuts, acorns, beechnuts, black walnuts, buds and other natural foods, often supplemented by corn grown in adjoining fields.

5. *Field borders in relation to wildlife*

Next to woodlots, field borders provide the most extensive semi-permanent type of cover available to wildlife in Ohio. They offer some of the best possibilities for developing a wildlife habitat improvement program. They are of much value in providing various types of cover and food for animals living part or full time in such cover and they also function as travel lanes for animals in going from one area to another. Field border travel lanes thus make it possible for some animals to utilize areas that would otherwise be unavailable to them.

Many investigators have noted the value of brushy field borders in providing cover for birds. In Ohio, Dambach (1945) found that field borders composed largely of woody plants, are occupied by many more nesting birds and beneficial mammals such as the short-tailed shrew than are nonwoody borders. Conversely he found that borders, consisting largely of blue-grass, supported high populations of destructive species such as the meadow vole, pine mouse, lemming, prairie white-footed mouse and house mouse. In Wood County, Leedy (1940) found that dense, brushy fencerows were utilized by pheasants in winter 30 times more than clean fencerows in the same area. The brushy fencerows were also found to be much more valuable as travel lanes than clean or sodded field borders.

In intensive field border studies made in southwestern Ohio, Dambach (1945) learned that shrubby fencerows less than four feet in width and six feet in height had little effect on the yields of adjacent crops. He found that "the more nearly the vegetation in a crop field border is related to the adjacent crops, the greater is the danger of its serving as a center for infestation of crops by insect and small mammal pests". It seems obvious from these findings that some type of shrubby field border is to be desired for wildlife between or adjactent to grain and forage crops and that sod or herbaceous types of field borders are less harmful around orchard crops. Dambach's studies also point out the need for further research in developing shrubby plants that will be easily managed, provide adequate wildlife cover and not compete with adjoining crops.

Fences of one type or another become an essential part of the farm habitat whenever livestock is included in the agricultural program. For the most part there is some conflict or competition between livestock and wildlife. Pasturing, cutting and burning are the three practices which are responsible for keeping more than one-half of Ohio's fencerows so clean that they contribute little to the production of game animals. Cutting, burning and other fencerow cleaning operations have been shown to be effective in controlling only a relatively few crop pests but these operations effectively reduce food and cover for wildlife and result in some mortality and nest destruction.' Obviously most fences are built to hold stock or to form property lines between farms. The ratio of fenced and fenceless field borders serves as an indicator of the relative amount of pasturing done in different counties. In livestock and dairying areas the percentage of fields with fences is high; in cash grain crop areas the percentage of fields with fences is relatively low.

In 1939–1940 a survey (Leedy, 1940) was made of some 16,800 fencerows in 24 counties scattered throughout Ohio. This study indicated that unfenced, and therefore unpastured, field borders often contained more cover than fenced field borders.

In Wood County, it was found that only 38 per cent of the fields were separated by fences compared to 93 per cent in Madison County. Wood County has a relatively high pheasant population and Madison County, a relatively light pheasant population. It is likely that the different agricultural practices followed in these counties and reflected in the number of pastured fields are partly responsible for the differences in the population of pheasants and other wildlife.

During the 1939–1940 survey fencerows were evaluated according to their potential winter cover for pheasants. Only 816 of them (4.8 per cent) were considered as providing superior winter cover consisting largely of shrubs, sprout growth and briers. Dambach (1945) recorded only 5.9 per cent of the field borders in his study area as shrub borders. It is apparent that much remains to be done to develop Ohio's field borders so that they will contribute to larger wildlife crops.

Interesting also are the kinds of fences observed in the above-mentioned survey (Leedy, 1940). Of 2,692 fences classified in 20 Ohio counties, the following percentages were noted by type: wire, 81.94; barbed wire, consisting of two or more strands, 13.71; electric, 1.75; rail fence, only .67; other fences, 1.93. The decrease in use of the rail fence has very probably been detrimental to such species as chipmunks. Electric fences have been unfavorable to wildlife inasmuch as they make it possible to quickly fence an area for pasturing and result in fewer permanent field borders. A survey made in Wood County, 1938, showed that approximately 15 per cent of the corn fields were pastured after having been picked. Of these pastured corn fields 42 per cent were partially or entirely enclosed by electric fences (Leedy, 1939).

6. *Miscellaneous practices and trends as they affect wildlife*

In addition to the wildlife-landuse relations pointed out above certain other practices and trends should be mentioned. Among these are the soil conservation practices including strip cropping, contour cultivation and land planning in which acreages of row crops are reduced and acreages devoted to forestry, wildlife and pasture are increased. Soil conservation practices resulted in net gains of 37.7 per cent and 44.9 per cent respectively of breeding birds on demonstration areas in southeastern Ohio and southwestern Ohio (Good and Dambach, 1943).

In the northwestern Ohio oil fields in former years, thousands of "rod lines" radiated from hundreds of engines transmitting power to the oil well pumps. These iron rod lines cut across fields in such a way that numerous odd corners were left to grow up to weeds and brush thus providing valuable game coverts in addition to the strips of cover left along the rod lines themselves. These rod lines are being taken up now that the oil is gone and large fields are being substituted for the numerous small and odd-shapped fields that once provided a greater variety of cover.

Strip-mining is becoming more general in the eastern Ohio coal fields. Thousands of surface acres have been and are being stripped of coal by power shovels which leave the raw overburden in series of steep-sloped ridges. Studies now being made in Ohio by Charles V. Riley, graduate student at the Ohio State University, as well as investigations made in other states indicate good possibilities of developing these areas for wildlife and forestry.

The development of new varieties of agricultural crops have both beneficial and detrimental effects on wildlife. Generally speaking the greater the yield of a given crop the more waste there will be left as wildlife food when the crop is harvested. However, some of the hybrid corn now grown, for example, stands up better and is picked cleaner than older varieties which yielded less per acre. An earlier maturing variety of timothy (Huron) is now being grown on a small scale in Ohio. If timothy and other hay crops were harvested earlier, the destruction of pheasant nests would be greater than it is now since more unhatched nests would be present at haying time.

Harvesting methods are an important influence on wildlife because of their effect on food and cover as pointed out earlier and also because of the resulting destruction to wild animals and their nests. Pheasant casualties as a result of hay mowing increased approximately 60 per cent from 1938 to 1946 mainly because of the increased use of power mowers. Careful counts made in 590 acres of alfalfa cut for Wood County dehydrating mills in 1946 revealed 106 adult female pheasants and 74 juvenile pheasants which had been killed by mowers. A total of 193 other dead vertebrates including 37 cottontail rabbits, were also killed. (Leedy and Dustman, 1947).

The destruction of unhatched nests together with such casualty rates indicate the importance of establishing undisturbed nesting areas as a part of a pheasant and rabbit management program. Investigations devoted to the development of an efficient type of flushing bar which would save many of these animals from being killed, would also seem to be justified.

The practice of clipping small grain stubble fields following the harvest is becoming more prevalent. Clipping the stubble reduces the amount of fall and winter cover available, decreases the amount of food and apparently decreases the attractiveness of the cover in the next year's hay crops for pheasant nesting.

SUMMARY

1. Protective and restrictive game legislation, artificial propagation and restocking of game, and establishment and maintenance of game refuges have been inadequate in keeping the supply of game in Ohio sufficiently high to meet the growing demands of the hunters.

2. Recognizing the food and cover requirements of the species, habitat development is recommended as a practical approach to the problem.

3. Changes in the Ohio environment due to settlement and development have brought about marked changes in the flora and fauna. Many typically forest

animals were extirpated, while other animals, more adapted to the changed environment, moved into Ohio or increased in numbers after the country was settled.

4. Although Ohio's wildlife is held in trust by the State for all the people, the bulk of the wildlife is produced as an unplanned crop on privately-owned farms.

5. The landowner is in a key position to manage wildlife through his control of the natural habitat but has little incentive for so doing without some assistance, financial or otherwise, from the army of sportsmen which desires hunting privileges.

6. Wildlife-land use relationships which are involved in the development of a wildlife management program based on habitat improvement, are discussed under the following headings: (a) cultivated crops as wildlife food; (b) harvesting methods as they affect the availability of cultivated crops for wildlife foods; (c) agricultural crops as wildlife cover; (d) Ohio woodlots and forest areas in relation to wildlife; (e) field borders in relation to wildlife and (f) miscellaneous practices and trends as they affect wildlife.

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Elementary Geography

Geography Around the Home is the name of a taxt for the youngest readers. Its aim is to give children an understanding of the involved transportation, agriculture, industry, and commerce surrounding the commonest acts of every day life. That the book can accomplish so much in its circumscribed space is due to the skill of its authors who know how to omit without offensive over-simplification. In the absence of maps, graphs, or tables of statistics, necessary tools for the higher levels, it aims to prevent a large array of the fundamentals of community living and interregional dependence. One author is Professor of Geography at Miami University, the other a gifted story teller and editor. The reviewer's interest was captured by the problem of how early human ecology can be introduced in the learning process. Carefully selected photographs and drawings by Helen John make a useful and pleasing book.—*A. E. Waller*.

Rand McNally Company—Chicago, 1947.

STAIN COMBINATIONS IN LIVING INSECTS

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The commonly practiced method in stain technique on non-living material is the use of two types of stains. This proves valuable for differentiation of portions of the tissue, for example, setting off the nucleus of the cell from the remainder of the protoplasmic material, as well as other portions of cellular structure. From past experience standards have been set up whereby certain stains are suggested for certain cellular structures or tissues. In the test series discussed in this paper the two general factors taken into account (besides the choosing of stains previously found good for viable tissue) were the acidity or basidity of the stain materials and the coloration, either of a red type or of a blue type.

The present paper is an expansion of the method developed by the author (1946[1]) for differentiating organs and tissues by injection of dilute stains in living animals. In the present experimental series two stains instead of one were used. The series was selected so that in each combination of two stains, one would be of a shade of red and one blue and at the same time one would be acidic in composition and one would be basic. Curiosity was the factor which prompted the author to use red-blue, acidic-basic mixtures of stains to see what shades of color might be obtained upon gross examination of the body organs and tissues and what dominance of one shade over another would appear in such a mixing process. Each individual staining solution was not tested to determine its relative acidity or basidity, but was used from its general classification as an acid or base material. Normal saline (0.85% aqueous solution of sodium chloride) was used as the medium for all the materials.

The materials used were those previously found useful as vital stains with definite color properties and not seemingly too injurious to the insect tissues. Twelve stain materials (dry) were chosen, made into solutions individually with normal saline as the medium, and mixed immediately before injection into the insect. Some difficulty was encountered in the beginning of the work due to the chemical activity of some materials upon mixture; some, allowed to stand for as much as five or ten minutes, would form a thickened or congealed solution which proved difficult to inject as well as toxic to the experimental animals. For this reason the practice of mixing the stain solutions just before injection by the hypodermic needle was used, and, except in four cases, no further serious difficulty was encountered.

The stains used are listed below, followed by their acidic or basic classification:

Bordeaux Red (acidic).
Rose Bengal (acidic).
Biebrich Scarlet (acidic).
Congo Red (acidic).
Safranine O (basic).
Fuchsin Basic (basic).

Blue de Lyon O (basic).
Brilliant Cresyl Blue (basic).
Azur II (basic).
Toluidin Blue (basic).
Aniline Blue (acidic).
Trypan Blue (acidic).

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[1] Research work done with the guidance of Dr. C. H. Kennedy, of the Department of Entomology, Ohio State University.

These were used to make twenty combinations (by twos):

Bordeaux Red x Blue de Lyon O.
Rose Bengal x Brilliant Cresyl Blue.
Biebrich Scarlet x Azur II.
Congo Red x Toluidin Blue.
Aniline Blue x Safranine O.
Trypan Blue x Fuchsin Basic.
Bordeaux Red x Brilliant Cresyl Blue.
Bordeaux Red x Azur II.
Bordeaux Red x Toluidin Blue.
Rose Bengal x Blue de Lyon O.
Rose Bengal x Azur II.
Rose Bengal x Toluidin Blue.
Biebrich Scarlet x Blue de Lyon O.
Biebrich Scarlet x Brilliant Cresyl Blue
Biebrich Scarlet x Toluidin Blue.
Congo Red x Blue de Lyon O.
Congo Red x Brilliant Cresyl Blue.
Congo Red x Azur II.
Aniline Blue x Fuchsin Basic.
Trypan Blue x Safranine O.

Each stain material was weighed and combined with normal salt solution at the rate of 1 gram dry material to 100 cc. normal saline. A small amount of each staining solution used in a combination was mixed with a similar amount of the other material used and the injections of .1 cc. were taken from this mixture. An experimental attempt to inject each stain solution separately proved destructive to the experimental insects both from the puncturing of the body wall by the hypodermic needle and the excessive amount of material introduced into the body cavity.

The experimental insect used in all the work was the American cockroach (*Periplaneta americana*). Under six months of age, the roaches do not prove to be good experimental subjects, consequently only those over six months or fully mature adults were used. These were taken from laboratory cultures where the age could be determined to a close degree.

After the solutions were made from the dry materials seven of them (Brilliant Cresyl Blue, Blue de Lyon O, Trypan Blue, Toluidin Blue, Azur II, Aniline Blue and Congo Red) made homogeneous mixtures as discerned by the eye. The last, Congo Red, was rather thick, and upon revolving the container rather large clumps of material were found clinging to the glass walls. Some settling occurred in Safranine O, Biebrich Scarlet and Bordeaux Red, the last only to a slight degree. In the case of Fuchsin Basic and Rose Bengal the solution appeared thin upon standing for a period of time with a large amount of settling in the bottom of the bottle. While all were shaken before use, these last two mentioned required additional agitation to thoroughly mix the solution. Upon examination all these stain solutions appear to be suspensions of greater or lesser degree rather than true dissolved materials. This is especially noted in the cases where settling occurred.

In the combinations made from the stain solutions those containing Congo Red and Toluidin Blue proved to be the most difficult in the attempts to obtain mixtures. Five of them were definitely thick, viscous liquids. These were Congo Red and Toluidin Blue, Bordeaux Red and Toluidin Blue, Biebrich Scarlet and Toluidin Blue, Congo Red and Blue de Lyon O, Congo Red and Brilliant Cresyl Blue. The remainder of the combinations formed more or less free liquid mixtures, although the appearance of granules or small flakes of material appeared in many of them. The ease of mixing and the thickness of the resulting combination may well be a very important factor in the value of the stain combination from the standpoint of mortality as well as coloring of structures.

METHODS

Insects of proper age were chosen from the laboratory cultures, indiscriminately as to sex, and removed to an anesthetizing jar. A piece of cotton or cheesecloth saturated with ethyl ether was placed in the jar, a tight cover placed over the top, and the insects left until rapid movement of the legs had ceased. By this time the insects were usually lying on their backs and producing slight movements with their bodies and legs. This was done only when everything was ready for the injections to be made because the roaches will recover quickly when they are the recipients of fresh air.

When calmed so that rapid movements of the legs, etc., would not impede the insertion of the hypodermic needle, the insects were taken out of the anesthetizing chamber and .1 cc. of the mixture to be tested was placed in the body cavity by puncturing the thin cuticle at the base of the third abdominal segment, using a 1 cc. hypodermic with a very fine needle. A rather slow release of the solution in the barrel proves best to prevent injury to internal organs.

The insects were then placed in "housing jars" (i. e., small culture jars) to await the time of dissection which was set at one-half hour, one day, and two days from the time of injection. Before dissection ether was again used to stop rapid movement until the legs could be removed and the ventral wall opened and spread apart on a small dissecting tray. Examination took place under a binocular microscope, as well as with the naked eye. The results of the gross examination of the internal structures is recorded for each stain combination.

RESULTS

The stains used had been selected with the view in mind of their good record previously of low mortality. However, some trouble was encountered in the use of four combinations. These were Safranine O and Aniline Blue, Rose Bengal and Toluidin Blue, Congo Red and Blue de Lyon O, Congo Red and Azur II. While no difficulty was apparent at one-half hour intervals, attempts to have survival of injected insects for one and two day periods necessitated many more trials than was the case with any of the others of the series.

Certain expressions used in connection with the descriptions of stain results to identify structures are of common recognition and do not need further explanation while others are those used by the author to clarify differentiated areas. The terms salivary glands, oesophagus, stomach, gizzard, malpighian tubules, tracheae, fat bodies, leg muscles, femurs, ovaries, testes, gastric caecae, ventral nerve cord are ones easily identified in the roach from a previous study of its internal structures or those of many of the other common insects. The terms "dorsal wall material" and "ventral wall material" refer to the fatty tissue lying next to the body wall of the respective surfaces. These quite often appear to be the same color as the fat bodies lying in the abdomen, but in a few cases differ in shade or color. The intestine portion of the digestive tract has been divided into three determinations. The "entire intestine" is used when the same shade is found throughout the entire length of the intestine; "upper intestine" for the upper half (using caudal-anal direction) and "lower intestine" for the lower half (if a smaller area is considered, it is designated as one-third, one-fourth, etc.). The words "heart outline" are used when a color appears to form an outlining band along either side of the heart area. The term "entire heart" includes both the true heart and the dorsal aorta, "true heart" the heart proper, and "dorsal aorta" the portion usually designated as such. "Heart wing muscles" is used for those V-shaped muscles, whose base is toward the heart, extending from the heart outward along the tracheae.

Each of the stain combinations were tested over a period of two days at the most. Dissections and examinations were made at intervals of one-half hour, one day and two days. In the records of this testing, the descriptions have been arranged in such a way that the time interval giving the best results from the standpoint of color variety and the number of structures shown to be affected is given first under the appropriate heading, with the introductory words *Best timing*. In this portion each of the organs and tissues affected are presented with the color noted in the examination. This part is followed by information of the other two time intervals with the structures affected and the colors represented merely listed.

In a review of the various combinations it has been noted that only three out of the twenty used showed a dominance of blue shades, i. e., including blue, violet, etc., more than red, rose, pink, etc. Toluidin Blue was the "blue" stain used in each of these (Congo Red x Toluidin Blue, Bordeaux Red x Toluidin Blue, Biebrich Scarlet x Toluidin Blue). In nine combinations the "red" predominated and in eight the red and blue shades were about equal. It might be noted that two, Safranine O and Aniline Blue, were used only twice each in combination with another stain, and the red shades were dominant in the resulting four sets of the test series. In all the combinations lavender was one of the colors appearing on the affected structures. No other color or shade was found throughout the entire series.

ROSE BENGAL X TOLUIDIN BLUE

Best timing: One day—salivary glands, deep lavender; oesophagus, stomach, gastric caecae, light violet; gizzard, violet; intestine, violet to lavender; malpighian tubules, deep red (wine) or deep purple; heart outline, heavy purple, with outer edge lavender; entire heart, ventral nerve cord, rose; dorsal wall material, rosy-violet or fuchsia; ventral wall material, fuchsia; fat bodies, bright blue with some lavender shading; leg muscles, femurs, lavender; ovaries, rose to lavender.

Half hour—Structures: salivary glands, oesophagus, stomach, gizzard, gastric caecae, intestine, malpighian tubules, entire heart, dorsal and ventral wall material, fat bodies, leg muscles. Colors: violet, lavender, blue.

Two days—Structures: salivary glands, stomach, gizzard, gastric caeace, intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies, leg muscles. Colors: lavender, pink, purple, violet, rose, blue.

ROSE BENGAL X BLUE DE LYON

Best timing: One day—salivary glands, lavender; stomach, gizzard, violet tinge; gastric caecae, light violet; intestine, mostly violet; malpighian tubules, one-half scarlet; entire heart, pink and violet blended (whole looks purple); dorsal wall material, deep violet; fat bodies, one-third violet, rest bright pink; spermatotheca, dark lavender to violet.

Half hour—Structures: salivary glands, oesophagus, stomach, gizzard, gastric caecae, intestine, entire heart, dorsal wall material, fat bodies, leg muscles, testes. Colors: lavender, violet, dark red, scarlet, purple, orange.

Two days—Structures: salivary glands, stomach, gastric caecae, intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies, ventral wall material. Colors: lavender, rose, scarlet.

BORDEAUX RED X TOLUIDIN BLUE

Best timing: Two days—Gizzard, intestine, deep purple; gastric caecae, dark lavender (extended); malpighian tubules, deep wine red; entire heart, deep purple (color flakes present); dorsal wall material, greenish blue; fat bodies, mostly pale blue; leg muscles, femurs, dull green; ovaries, yellow-green; ovarian tubes, light to median blue; ventral nerve cord, blue tinged, darker at ganglia.

Half hour—Structures: salivary glands, gastric caecae, malpighian tubules, entire heart, dorsal wall material, fat bodies. Colors: purple, blue, lavender, rosy-lavender, violet, pink.

One day—Structures: salivary glands, stomach, gastric caeace, upper intestine, malpighian tubules, heart outline, dorsal wall material, fat bodies. Colors: purple, blue, lavender, red, violet.

SAFRANINE O X TRYPAN BLUE

Best timing: Two days—salivary glands, light lavender; gizzard, upper part pink, lower part lavender; gastric caecae, leg muscles, deep rose; intestine, rosy lavender tinge; malpighian tubules, one-half rose; heart outline, heart wing muscles, violet; entire heart, dark purple; dorsal wall material, salmon (some pink); ventral wall material, lavender; fat bodies, pink; ovaries (and tubes), rosy lavender.

Half hour—Structures: salivary glands, stomach, gizzard, intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies, leg muscles, testes. Colors: lavender, rosy lavender, red, pink, salmon.

One day—Structures: salivary glands, stomach, gastric caecae, upper intestine, entire heart, dorsal wall material, fat bodies. Colors: pink, lavender.

BIEBRICH SCARLET X BRILLIANT CRESYL BLUE

Best timing: Half hour—salivary glands, light violet; stomach, reddish; gizzard, lavender; gastric caecae, slightly reddish; entire heart, heart wing muscles, dark purple; dorsal wall material, bright pink to lavender; fat bodies, pink, lavender and violet; leg muscles, bright pink streaks; testes, pale to bright blue.

One day—Structures: salivary glands, malpighian tubules, entire heart and outline, dorsal wall material, fat bodies, leg muscles, ovaries. Colors: pink, dark red, brown, orange, blue, lavender.

Two days—Structures: salivary glands, gizzard, gastric caecae, upper intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies. Colors: lavender, pink, red, brown, blue, salmon.

CONGO RED X TOLUIDIN BLUE

Best timing: Two days—salivary glands, faint blue tinge; stomach, lower one-third light lavender; gizzard, lavender; gastric caecae, faint lavender tinge at base; intestine, deep lavender with some light purple portions; malpighian tubules, lavender (granular appearance); heart outline, heavy dark purple with heavy violet accumulation along edge; heart wing muscles, purple to violet; dorsal wall material, very bright blue, some bright violet immediately along tracheae; ventral wall material, yellowish blue; fat bodies, mostly pale to bright blue in abdomen, few light violet spots. Presence of dark purple flakes noted in center of body.

Half hour—Structures: gastric caecae, intestine, fat bodies, testes. Colors: lavender, purple, blue, red.

One day—Structures: salivary glands, stomach, gizzard, gastric caecae, intestine, heart outline, dorsal and ventral wall material, fat bodies. Colors: blue, lavender, violet, black.

BIEBRICH SCARLET X BLUE DE LYON

Best timing: One day—salivary glands, stomach, lavender; gizzard, gastric caecae, leg muscles, light lavender; upper intestine, deep lavender (almost purple); malpighian tubules, orange-red; entire heart, deep blue; dorsal wall material, lavender tinges; ventral wall material, mostly deep blue.

Half-hour—Structures: salivary glands, stomach, gastric caecae, dorsal aorta, dorsal wall material. Colors: lavender, orange, pink.

Two days—Structures: stomach, intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies. Colors: blue, lavender, orange-red, pink.

FUCHSIN BASIC X TRYPAN BLUE

Best timing: Two days—salivary glands, lavender; gizzard, bluish tinge; gastric caecae, lavender tinge; malpighian tubules, lavender to scarlet (granular); dorsal aorta, femurs, purple; heart wing muscles, purple; fat bodies, faint blue tinge in thorax, some lavender tinge in abdomen; leg muscles, deep blue.

Half-hour—Structures: salivary glands, stomach, malpighian tubules, dorsal aorta, testes. Colors: lavender, rosy lavender, pink, scarlet.

One day—Structures: salivary glands, gizzard, gastric caecae, malpighian tubules, dorsal aorta, dorsal wall material, leg muscles, ovaries. Colors: lavender, blue, scarlet.

BORDEAUX RED X BRILLIANT CRESYL BLUE

Best timing: Half hour—salivary glands, deep bright blue; gizzard, lavender tinge; gastric caecae, purple tinge (enlarged); malpighian tubules, dull wine red; entire heart, red tinge; heart wing muscles, deep purple with spot of orange-red in centér; fat bodies, in abdomen ventral side pink to deep lavender, dorsal side pink, bright pink and lavender; leg muscles, deep blue; oviducts, light blue.

One-day—Structures: salivary glands, gastric caecae, upper intestine, malpighian tubules, heart outline, dorsal wall material, fat bodies. Colors: pink, scarlet, red, violet, purple, lavender, blue.

Two days—Structures: malpighian tubules, heart outline. Colors: red, lavender.

ROSE BENGAL X AZUR II

Best timing: Half hour—salivary glands, lavender; stomach, partially violet; gastric caecae, dark orange; intestine, orange; malpighian tubules, rose and orange; entire heart, purple; heart wing muscles, light purple; dorsal wall material, rose-pink to lavender; fat bodies, bright rose (almost scarlet) to violet.

One day—Structures: salivary glands, gizzard, gastric caecae, upper intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies, ovaries. Colors: lavender, pink, rose.

Two days—Structures: gizzard, gastric caecae, intestine, malpighian tubules. Colors: blue, rose, violet.

CONGO RED X BLUE DE LYON

Best timing: Half hour—salivary glands, lavender; stomach, gizzard, intestine, gastric caecae, dark red-brown; entire heart, heart wing muscles, maroon; dorsal wall material, dark purple; fat bodies, pink or lavender tinged; testes, dull pink.

One day—Structures: salivary glands, stomach, malpighian tubules, entire heart, dorsal wall material, fat bodies, gastric caecae. Colors: lavender, rust (orange-brown), salmon, orange. General appearance is salmon.

Two days—Structures: salivary glands, stomach, gizzard, intestine, malpighian tubules, heart outline, fat bodies, gastric caecae. Colors: lavender, blue.

SAFRANINE O X ANILINE BLUE

Best timing: One day—salivary glands, lavender (with bright orange "veins"); gastric caecae, bright rose; intestine, one-half rosy lavender; malpighian tubules, bright orange-red; entire heart, lavender tinge; heart wing muscles, light lavender; dorsal wall material, salmon to median orange; fat bodies, salmon; leg muscles, deep pink; ovarian tubules, partially blue; nerve cord ganglia, pink tinge. Overall appearance is salmon.

Half hour—Structures: salivary glands, stomach, gastric caecae, malpighian tubules, dorsal wall material, fat bodies. Colors: pink, orange.

Two days—Structures: stomach, gastric caecae, intestine, dorsal and ventral wall material. Colors: bluish-green, orange-red, pink, lavender, rose.

FUCHSIN BASIC X ANILINE BLUE

Best timing: Two days—salivary glands, very light blue; stomach, spots of blue and lavender; gizzard, gastric caecae, medium blue; intestine, dark lavender to purple or blue; malpighian tubules, light purple or fuchsia (with minute dark granules); entire heart, dorsal wall material (mostly), testes, light blue; heart wing muscles, very light blue.

Half hour—Structures: salivary glands, stomach, gizzard, gastric caecae, malpighian tubules, entire heart, dorsal wall material. Colors: blue, lavender, orange-brown, pink, rose.

One day—Structures: salivary glands, gizzard, lower intestine, malpighian tubules, entire heart, dorsal wall material, femurs. Colors: blue, lavender, scarlet.

BIEBRICH SCARLET X TOLUIDIN BLUE

Best timing: One day—salivary glands, very dark lavender; stomach, lower one-half light purple; gizzard, lavender; gastric caecae, tips violet; intestine, small portion blue with rest lavender; malpighian tubules, uncolored or with some portions deep wine red; heart outline, violet; heart wing muscles, heavy violet; dorsal wall material, mostly light blue; fat bodies, creamy, pale, medium or dark blue or violet. Globules of dark blue material through body.

Half hour—Structures: salivary glands, stomach, gizzard, intestine, entire heart, dorsal wall material, fat bodies, leg muscles. Colors: violet, purple, blue.

Two days—Structures: gizzard, gastric caecae, intestine, malpighian tubules, heart outline, dorsal wall material, fat bodies. Colors: lavender, purple, blue, violet.

ROSE BENGAL X BRILLIANT CRESYL BLUE

Best timing: Half hour—salivary glands, deep rose-lavender; gastric caecae, slight pink tinge; malpighian tubules, pale to light, bright blue; dorsal aorta, anterior one-fourth rose, remainder deep lavender; dorsal wall material, rose lavender; fat bodies, posterior one-third (abdomen) pink, rest deep rose and lavender combination; leg muscles, light blue tending to lavender; femurs, scarlet.

One day—Structures: gizzard, gastric caecae, intestine, malpighian tubules, entire heart, fat bodies. Colors: lavender, red, light blue, rose.

Two days—Structures: gastric caecae, upper intestine, heart outline, dorsal wall material, fat bodies. Colors: red, pink, brown, blue.

BORDEAUX RED X BLUE DE LYON

Best timing: One day—salivary glands, lavender (with blue "veins"); stomach, fat bodies, dark blue streaked; intestine, traces of light violet; malpighian tubules, light rosy lavender; heart outline, heavy blue coloring at entrances of tracheae (granules present); dorsal wall material, some pale lavender tinges with some scattered blue spots; ovaries, deep lavender with few blue spots.

Half hour—Structures: salivary glands, lower intestine, malpighian tubules, heart outline and entire heart, fat bodies. Colors: lavender (pale and reddish), blue, red, scarlet.

Two days—Structures: gastric caecae, malpighian tubules, heart outline, fat bodies, ovaries. Colors: blue, scarlet, dull red, lavender.

BORDEAUX RED X AZUR II

Best timing: One day—gastric caecae, light green tinge; intestine, mostly purple; malpighian tubules, one-half very faint pink; heart outline, brown pigmented; dorsal aorta, orange-pink; heart wing muscles, light tan; fat bodies, tinges of light blue and light pink.

Half hour—Structures: salivary glands, stomach, malpighian tubules, entire heart, dorsal wall material, testes. Colors: lavender, pink, red, blue.

Two days—Structures: gastric caecae, malpighian tubules, intestine. Colors: red, bright yellow, violet, lavender.

CONGO RED X AZUR II

Best timing: Two days—gastric caecae, upper intestine, faint pink; heart outline, dark brown (flaky material); heart wing muscles, light orange-brown; dorsal wall material, salmon (scattered spots between tracheae); ovaries, few orange spots. Clumps and flakes of very dark reddish brown material through body cavity.

Half hour—Structures: salivary glands, entire heart. Colors: pink, yellowish brown. Brown flakes scattered through body.

One day—Structures: salivary glands, upper intestine, entire heart, dorsal and ventral wall material, fat bodies, leg muscles. Colors: blue, lavender, violet, rosy lavender. Dark violet (crystalline) material found in spots on dorsal side of fat material.

CONGO RED X BRILLIANT CRESYL BLUE

Best timing: One day—salivary glands, pale lavender; heart outline, heavy brown pigment; dorsal aorta, some orange (deeper than normal); heart wing muscles, orange-brown (brown specks present); dorsal wall material, salmon; oesophagus, stomach, gizzard, gastric caecae, intestine, orange. Impression of body cavity taken as a whole is of a salmon color; this is especially true to the naked eye.

Half hour—Structures: salivary glands, entire heart, dorsal wall material, fat bodies. Colors: lavender, violet, red, pink. Dark brown flecks through body cavity.

Two days—Structures: salivary glands, gastric caecae, intestine, malpighian tubules, entire heart, dorsal wall material, fat bodies. Colors: pink, orange-red, red, orange, orange-yellow. Brown pigment through body cavity. Body cavity as a whole looks orange.

BIEBRICH SCARLET X AZUR II

Best timing: Half hour—salivary glands, light, bright blue; malpighian tubules, few posterior ones light blue, few dull red (with minute red granules); heart wing muscles, purple; fat bodies, portions of pink and blue (light); leg muscles, pale blue; testes, light blue.

One day—Structures: stomach, intestine, malpighian tubules, testes. Colors: lavender, deep red, rose.

Two days—Structures: gastric caecae, intestine, malpighian tubules, heart outline. Colors: purple, violet.

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Conn, H. J. 1940. *Biological Stains.* 4th ed. Biotech Publications, Geneva, N. Y.

Hershberger, R. V. "Differential Stains of Insect Tissues." Ohio Jour. Sci., 46: 152–162 May, 1946.

History of the Grasslands of North America

These two books which must be read together to form a fair appraisal of the author's intention, present the first really important bibliography of the natural conditions of the central region of the United States. In preparing his manuscripts some 2500 titles of primary sources have been carefully reviewed. The ecologists as well as the geographers and agronomists will find a wealth of background material which cannot be overlooked any longer as exploration and exploitation give way to the responsibility of dealing with an environment which contrasts so markedly from the eastern forested land areas. The author's concept of the grassland formations is strikingly like that of the early competent description and emphasizes the same plant types made familiar in the writings and lectures of John H. Schaffner. The second part of the work owes its inspiration in great part to the publication of N. S. Shaler. The total impression left with the reader is a more complete and more reliable account than found in some of the modern ecologists' efforts. What makes Malin's work valuable to an understanding of the social implications of the grassland is the main thesis that social process is rooted to the environment. Only exceptional histories have revealed awareness of this relation.

It is unfortunate for the distribution of these books that a publisher who would bring the work to the attention of a large reading public was not selected. The books must be obtained directly from the author.—*A. E. Waller.*

(1) **The Grassland of North America.** (Prolegomena to its history), 1947.

(2) **Essays on Historigraphy, 1946.** Published by James C. Malin, 1541 University Drive, Lawrence, Kansas.

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THE FALLACY OF COMMUNISM[1]

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It is trite to say that the world is in a state of revolution, but triteness is an evidence of truth. Since the end of the first World War this revolution has beset us with conflicting ideologies and perennial conflict. There was no time between the two great wars when the world was wholly at peace. Fascism developed in Italy, extended to Germany, and tried its arms in Ethiopia and in Spain. The military leaders of Japan encroached upon Manchuria and involved China in a long war. Communism entered the arena and grew to a commanding position in Russia, fostering a policy of expansion which made it a threat to many other countries.

Of these ideologies Communism alone remains secure. Fascist Italy, Nazi Germany and the militarism of Japan have been put down by force of arms at great cost in life and resources while our erstwhile allies, the Russians, continue to thwart our efforts toward lasting peace and in doing so arouse our suspicion that the Cominform is no more than the Comintern in disguise and that infiltration of Communism into other countries is still being actively and insidiously promoted.

Under these conditions the security of our American way of life is constantly threatened. England, our natural European ally, has swung to the left in name as well as in fact and we, without acknowledging it in the labels that we show to the world, have exhibited strong leftist tendencies. Does this modern trend mean that we have been softened for ultimate absorption into acknowledged Communism? Does the gradual change indicate a normal shift in human relations toward that end? Must Communism be accepted at last whether some of us like it or not? And finally, are those of us who dislike the implication merely reactionaries? Do we fight the change because we are selfishly interested in our own way of life and unwilling to change for the benefit of mankind, or have we actually in America, rather than only another political ideology, a sound way of living to defend?

This subject may seem a strange choice for a scientist, since it is a living issue in the newspapers and magazines of the modern world, and as far as the methods of the Soviets and of the Communist Party elsewhere are concerned, it is indeed unlikely grist for the mill of science. But the relations of living things, whether other organisms or men, are a normal part of biology and biology can offer sound and pertinent information even on the affairs of men. The variations of political emphasis are immaterial. That communism may be a form of government by communes or the strange Russian autocracy which calls itself truly democratic, that the stated principles of Karl Marx have been badly abused in the development of the communism of today, need not concern us while the central principle remains the regimentation of individuals and the elimination of private capital. From every man according to his ability, to every man according to his need, even though it is a communist credo, is a principle of social living so fine, so simple, so basically sound and so amenable to scientific analysis that it is a sufficient point of departure.

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[1] Presidential address delivered before the Ohio Academy of Science, at the University of Toledo, Toledo, Ohio, May, 1948.

That science has not contributed more to the understanding of man and of human society seems incredible. Possibly the failure is the fault of scientists, possibly of those who are more actively interested and more directly involved in the relations of men. In either case we may agree with Dr. Robert R. Williams who says in an article entitled *Natural Science and Social Problems:*[2] "In social problems there is no appeal to natural science, and natural science as such seeks no opportunity to be heard." The entire article is well worth reading for its penetrating analysis of the social ills of mankind and the need for scientific understanding and methods in the study of human relations, but we cannot consider it in detail for our more limited purpose. Let it suffice to note that in it we find encouragement and an intelligent plea for such an application of biological knowledge as is undertaken here.

Every college student who takes an introductory course in biology encounters facts which are significant in his own life and relations but probably few of them carry these facts beyond their immediate presentation in the textbook and laboratory. I wonder how many of their teachers do more? These facts begin with a fundamental property of living substance: organization. When the student makes the acquaintance of the cell he is confronted with a complex structure whose varied parts are beautifully shaped and beautifully coordinated for the maintenance of the entire unit, and there begins the relationship which continues so intricately through the animal kingdom to man himself.

The cell may be self-sufficient, but we see among the colonial Protozoa that these self-sufficient cells may, from some unknown cause, band together to live in groups and in some of these minute colonies we see further possibilities of such a close association. A division of labor occurs. Some cells assume one duty, others another, and the greater unit is maintained and perpetuated through their joint activities. We ascend to the sponges and there find such complexity of specialization that biologists were once in doubt whether they should be considered highly organized protozoan colonies or true multicellular animals, but when we reach the Metazoa there is no question. The existence of a nervous system in these animals knits the many parts of the body so closely together in their cooperative activities that we may even lose sight of the perfection of fitness of their many tissues and organs and organ systems for the special functions that they carry on unless our work deals with such matters. But the individual is still a unit which depends for its normal existence on that perfect organization.

But this is not all. As cells may be either independent individuals or units in a colony, so may multicellular animals, and as cells in the colony or in the multicellular body may be sharply differentiated for a division of labor, so may these more complex animals within their colonies. The marine coelenterates afford many examples of such colonies, structurally continuous yet composed of many individuals whose activities are coordinated for the maintenance and reproduction of the group.

Even though individuals may remain structurally discrete, this principle of organization extends still further into a phylum which stands at one of the pinnacles of evolution—the phylum Arthropoda. Here in the social insects we find it perfectly expressed. It is an object lesson by which we have failed to profit as we should even though comparisons have been drawn between the social organization of the insects and of man often enough from many points of view.

Two orders of insects, the order Isoptera including the termites and the order Hymenoptera including the ants, bees and wasps, contain species with complex colonial organization. Their colonies differ in complexity and in permanence but at their maximum development they are very significant. In these colonies the individuals are not all alike. Their variation is not merely the variation of complex organisms such as we see in any species nor merely the differences of sex, but involves the existence of different castes, in the honey-bee colony the reproductive queen and drones and the sexually inactive workers, and in some other species a considerable diversity of forms which may bear little resemblance to each other. Individuals of each of these castes are shaped by heredity to carry on special functions and thereby to occupy a special niche in the colony. The coordination of their behavior is as nearly perfect as that of the component parts of the human body. They do not compete for individual advantage. As far as we know they do not quite their jobs nor strike for higher pay. They are utterly dependent on each other and if one caste fails in its duties all are ultimately doomed and the colony perishes. Each individual serves the colony according to its ability and each receives from the common stores whatever it needs.

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[2] Williams, Robert R., 1948. Natural Science and Social Problems, *American Scientist* 36(1), 116–126.

Just as the varied functions of one body are carried on by its parts, so are the duties of the colony delegated to the special castes, and nowhere more conspicuously than in reproduction. The drone honey-bees have no value save to fecundate the queens. The queen has no value save to deposit eggs and, oddly enough, neither parent has any instinctive urge to care for its own young. Yet the workers, which have no instinct to mate and do not normally deposit eggs, carry on the elaborately specialized tasks of rearing the young.

This is a perfection of communal life which we can well envy. It has been appreciated for many centuries, as the search for a utopian organization of men attests. Plato's *Republic*, in the fourth century before Christ, outlines such a perfect communism. The scriptures emphasize its principles. And finally Sir Thomas More, almost five hundred years ago, coined the word Utopia for his organization of men which should coordinate them as perfectly for the maintenance of society as any social insects.

One fact these thinkers failed to note. Perhaps they should have been biologists first and philosophers later! That fact is simple. The true biological communism of the insect colony is an inherent pattern of life shared by only a few kinds of animals and man is not among them. When we consider the ways of the mammals, of which he is one species, we find that most of them are solitary, a term which means to the biologist only that the individual is a self-maintaining unit on which the species is based. Each individual defends himself and finds his own food and such shelter as he may need. He has only one need for association with others of his kind—the need for a mate when the second great urge of life is active. All individuals may mate and beget young and in the resulting family the intensely selfish motivation of their lives is at least temporarily modified

This is the pattern of human life. Every human being is equipped by heredity with essentially the same structure as every other, barring the differences of sex. In the natural state each is self-sufficient and his motivation leads him to seek his own welfare first. Only in his family life is that motivation secondary. There nature has guaranteed the future of the species by shaping him to place the welfare of his dependents often ahead of his own. And since the long infancy of human beings results in the overlapping of a natural succession of children, the family becomes very nearly a lifelong preoccupation.

But even among the mammals a strongly gregarious tendency may develop. Man shares that tendency to a high degree and since he is an intelligent toolmaking creature his association paves the way for a division of labor far more complex than that of any social insect and thus he has arrived at his intricate social way of life. But his division of labor is based primarily on special training. He remains a versatile being who may do many tasks well and who can become discontented with his job or with his reward. To satisfy the inherent capacities which they do not satisfy he may want more than he can earn and in his search for satisfaction the natural allegiance to others which is basically expressed in his family may extend readily to his trade union, his village or his country, since their welfare and their security affect his own.

And man is pugnacious. The safety of the solitary animal demands that he be able to protect himself, but by some marvel of evolution that instinct has been directed in the social insects almost wholly to the defense of the colony. In man it is not so. He may fight his neighbor, he may fight for his union, and occasionally he fights magnificent wars, but the chip is still on his own shoulder whether it reveals itself in physical violence or in selfish diplomacy.

For these reasons the structure of human society rests on a foundation of quicksand. They explain our groping through the centuries for more nearly perfect relations among men. They explain the makeshifts and changes which promise so much and leave us in the end much as we were before. Citing Williams again, "we are doing no worse than in Roman times, merely no better." Man is simply not an inherently social animal and too many men fail to appreciate how they must behave as individuals to maintain a smoothly working society. They must be coerced by customs and laws and their inherent nature rebels at the coercion.

How, under such conditions, can man be communistic? Sir Thomas More regarded private property as the chief barrier to the attainment of his Utopia, as the basic reason for all of the lawless tendencies of men. He proposed a completely communal ownership of consumer's goods. Houses were not to be locked and freedom of entry was to be permitted. Every man might go to the centers of supply for the group and help himself to what he needed without making a direct return. The population was to eat in common dining halls in which the work was to be shared in rotation. Every human being was to work as long as he was able and then to continue into a happy and abundant old age. And his roseate plan extended into every detail of organization, freeing men from the established customs of his day as far as More could make the shift in his own mind.

It is a beautiful dream but we are still far from the utopian state for the simple reason that we are not utopian beings. Each of us is plagued by that versatility of the solitary animal. We conform to the social pattern by choosing a vocation and training ourselves to work at it, but once we have settled down to the routine of the job our unsatisfied urges clamor for expression, since few of us can express ourselves fully in one occupation. We need recreation, we cultivate hobbies, we seek entertainment which is usually a vicarious outlet for unfulfilled desires. Instead of finding the satisfaction of our biological needs adequate we work for the money and the leisure to secure in our avocations the expression of our latent capacities. And the individualism, or more bluntly the selfishness, of the solitary animal would result in our taking what we want far more freely than we do if the pressing need for restriction had not long ago imposed upon us the ethics and customs and laws that keep us within reasonable bounds of respect for the rights of others.

In the inherently communistic societies of insects these pressures are not felt. The individual is fitted by heredity for the performance of special tasks. Its structural adaptations and its mental patterns shape its course of life and it expresses its possibilities fully in the duties which it performs. It is not troubled by allegiance to its family, for even the process of reproduction is communal. The colony transcends the family and the individual as the multicellular body transcends the organs and tissues and cells which compose it. Both are maintained by the spontaneous coordinated activities of their subordinate parts and all of those parts share in the prosperity of the unit which they maintain. The individual does not have unexpressed capacities to be satisfied, it need not interfere with the rights of others, and no government is needed to keep it in line with the common good.

Man, however, probably found in his initial division of labor intensely personal advantages. His heritage fitted him to do certain tasks better and more easily than others and he could devote himself more fully and more happily to the exercise of his own special aptitudes by exchanging his efforts for the products of similar specialization in others. If social life could have remained such a simple barter it might have greater possibilities of attaining communistic perfection, but unfortunately it could not. Our tool-making has led us into an extremely complex pattern of specialization in which the activities of men are often remote from basic needs and their desires often far surpass their productive capacities. Our intelligence, too, enables us to assess future values which cannot bring the immediate returns needed by individuals and so we need some planning and coordination and regulation for the ultimate good of the group. We secure these results by governing bodies of one kind or another and in this factor also our society draws away from true communism.

The desires of the individual, to be satisfied largely by the acquisition of property, and his need for direction, have led to the hierarchy of private and political managements expressed on the one hand in our capitalistic industrial system and on the other in our increasingly complex governments. Both have led to abuses and from both have come our communistic ideas and experiments, which should ideally lead to common ownership of all goods but those most intimately personal and to a perfect coordination of individuals which would result in anarchy because governments would no longer be needed. That end would be the final degree of social perfection, for true communism is nothing less.

But we must not forget the mold in which we are cast. Man, the solitary animal, does not spontaneously fit into a given niche in the social order. He works to satisfy his needs and his desires, and since they are in many cases greater than the value of his work to others, he may be discontented with his lot. He is shaped like other men and as a result he finds it difficult to understand why his rewards are less. Here is the source of more discontent and of antagonism to others as well. If his intelligence is high he may adjust himself happily to his lot but human intelligence varies and by the normal law of variation it is average or less in a majority of the population and as a result many men are discontented with the existing order and desirous of change. Their natural allegiance to family and to the smaller groups with which their own welfare is obviously linked enables them to use the power of numbers through pressure groups of all kinds to secure what they want for themselves and their dependents. The question of the greatest good for the greatest number does not necessarily enter. Instead society struggles along through a balance of power between labor and capital, between political parties and between national governments and alliances.

Political communism begins with the sound premise that these frictions should be eliminated. First, the accumulation of wealth must be prevented. Private capital must go. The government becomes ostensibly the people's government, its property is therefore theirs, and we are on the road to Utopia. For if the worker cannot be exploited by the capitalist there can be no abuse of individual privilege. In transition to anarchy some government is necessary and capital is always needed even though it is government capital, but if it is the people's own government that holds the power, then each man has a share in its efforts and in its gains and the abuses of the past are at an end.

Men worked toward this ideal through the evolution of their governments in the past. At first government depended on the might of a ruler and the inarticulate and illiterate masses submitted because they must. Then leaders arose among them and over the route of the Magna Charta the common man gained some of the rights that he deserved and finally arrived at the democratic form of government so well developed in Switzerland and in the United States. Here every man who votes has a voice in the regulation of his own social group.

But the vote of the moron unfortunately carries the same weight as that of an intelligent man and the ruling majority may include far more men who are incapable of judging the issues at stake than intelligent voters simply because of the normal variation of mental capacity. And those less intelligent citizens are the ones most concerned with bettering their own lot and far less with their obligation to society. Any persuasive leader or attractive ideology that can promise them a more abundant life for less effort will gain their support. Hitler and Mussolini and the Russian leaders were persuasive and Fascism, Nazism and Communism appealed strongly to this class, for it has always been true that the support of an unthinking horde is needed to establish such revolutionary governments. The leaders of these movements are like other men. We have no reason to suppose that they are ideally interested in the welfare of their peoples to the exclusion of personal ambition and the thirst for power which are human expressions of the intense selfishness of the solitary animal. Enough of the people vote the new regime into power but only to find, tragically, that they have voted themselves into impotence and have reverted to a despotism probably little less than those which their ancestors fought to overthrow.

And so political communism is fallacious. Communal enterprises have worked on a small scale for fairly long periods, as in the Amana Society of Iowa, but Communism as we see it expressed today appears to be a bastard of the Fascist idea, the doctrines of Karl Marx, democratic principles of organization and dictatorial rule which seems removed only in outward form from actual despotism. But in any form communism is fallacious because of the biological nature of man. His retention of the characteristics of the solitary animals makes him an individualist. He demands self-expression. Yet he is an intelligent creature on the whole, who can see the value of the division of labor in his society. If he were so shaped that every man could spontaneously subordinate himself to the social group he might attain the semblance of communistic perfection but his selfish impulses are far more deeply rooted in his remote animal ancestry than his distinctively human qualities, and the more deeply rooted a tendency is in the evolution of an animal, the more spontaneously it is expressed. Perhaps, in the long course of our future evolution, the human species may become more fundamentally social. No evidence of such a trend can be seen at present, however, and certainly for a long time to come we must deal with man as he is today. What he needs for maximum social success is evidently a system of regulation which will guarantee him the necessities of life, enough opportunity for self expression to make him a happy contributing member of society and enough regimentation to bring this result as fully as possible to all men. But that is what the democracies have given him with a very reasonable degree of success, while Communism has accomplished far more in coercive regimentation than in opportunities for self expression.

Whatever man may do, since he is an organism, has a biological basis. His society is no exception. Because of this foundation man cannot be truly communistic. Any movement masquerading under that term is a wolf in sheep's clothing, for it promises what cannot be realized. The great theorists may have been honest in their ideals, but their biology was unsound. In the militant modern Communists we cannot even be sure of honest ideals, for the class antagonism that they preach is anything but true communism. But we are still fortunate in America, for the same biological foundation shows that our pride in our country is not based merely on patriotism nor on a selfish desire to perpetuate our own comfortable way of life but on the fact that it is ultimately, biologically, a superb if imperfect example of the successful adjustment of solitary man to social living. We may support it as militantly as need be in all confidence that it is a sound way to the realization of the ultimate destiny of man, whether that destiny may be a true communism or merely a more effective compromise between human beings with the same inherent nature as those of today and the requirements of a sound social organization. More coined the term Utopia to designate a nonexistent land. It is still nonexistent. In spite of the lavish promises of Communism it cannot be created by deliberate planning. It is an inherent pattern of life developed in the social insects as the result of a long course of evolution which took place while our own species evolved toward a very different end. And evolution is immune from ideological and legislative influences.

Political communism can appeal strongly to men of limited intelligence since it promises them what they cannot earn for themselves. Through the power of franchise, if not of arms, they may force it upon increasing numbers of men, but the very need for force is a contradiction of true communism and an indictment of the existing political ideology. At the best it can only prolong our struggle for friendly cooperation among nations. At the worst it can plunge the world into a despotism such as men struggled for centuries to overthrow. For these reasons, but basically and insidiously because it is a contradiction of the inherent biological nature of men, the whole fabric of political communism is fallacious.

Until more men can understand the fundamental nature of this fallacy the threat hangs over us. And the hope that enough men can attain that understanding may itself be a utopian dream.

A NEW SPECIES OF ISSIDAE FROM CALIFORNIA

(HOMOPTERA: FULGOROIDEA)

JOHN S. CALDWELL,
Circleville, Ohio,

AND

DWIGHT M. DELONG,
The Ohio State University

In the collection and study of the Homoptera occurring on grape in California two species of Fulgoroidea have been taken by Dr. Severin. One of these belonging to the genus *Hysteropterum* is apparently new and is being named in honor of Dr. Severin. He has furnished also the food plant data and collecting dates.

Hysteropterum severini n. sp.

Resembling *auroreum* (Uhler) but with flatter frons, longer elytra, and different male genitalia as noted in the description. Length, male, 4.5 mm.; female, 5.3 mm.

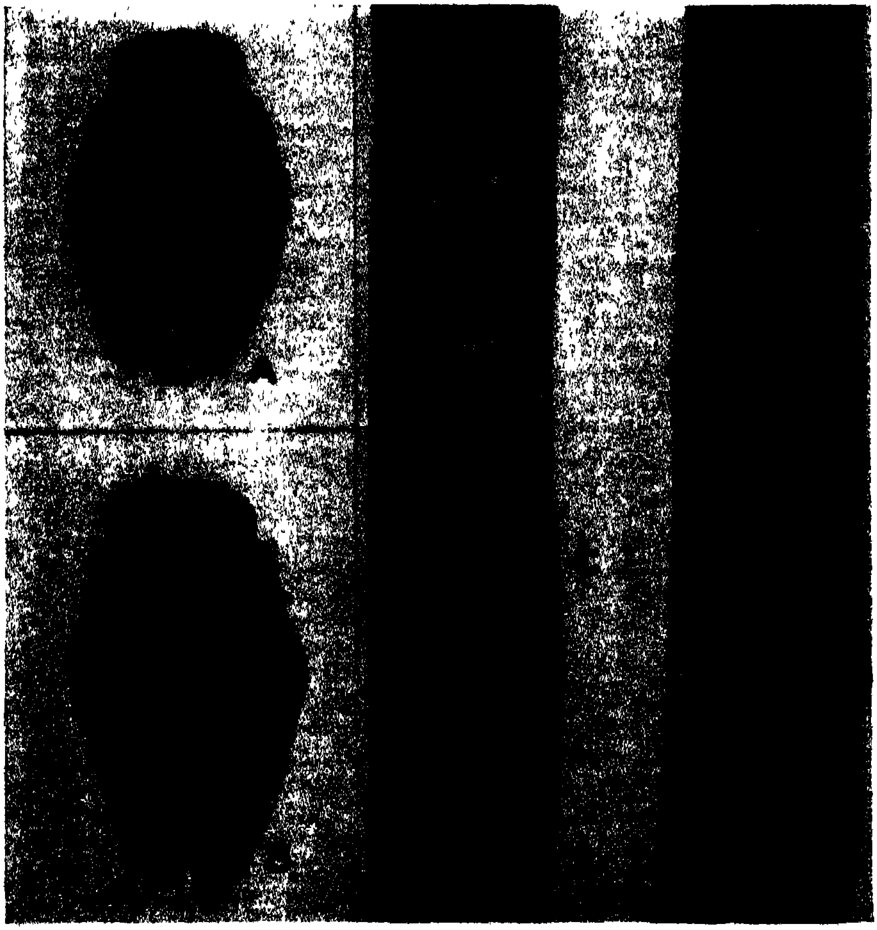
General color yellow to yellow-orange. Frons darkened between carinae. Elytra in female tending toward fuscous. Costal margin in both sexes broadly white.

Vertex three times as broad as long, quadrate, sharply carinate cephalad. Frons flat, without intermediate carinae. Clypeus scarcely protruding into frons. Elytra broadly bullate, longer than in *auroreum* (Uhler).

Anal segment of male bifid apically with lateral flaps projecting ventrad. Claspers with apical spur extremely elongate; heel narrow, half as long as apical spur. Aedeagus without apical spurs; ventral processes long, curved toward base of aedeagus with the extreme apices hooked dorsad.

Male holotype, female allotype, and paratypes of both sexes from Geyserville, Sonoma Co., California, collected on July 2, 1946, on California mugwort, *Artemesia vulgaris*, and on *Brickellia californica*. Paratypes were also common on olive trees and on coyote brush or chaparrol, *Baccharis pilularis*, July 2, 17 and 25, 1946, near Cloverdale, California, collected by H. H. P. Severin.

Dr. Severin also reports that egg masses were abundant on the trunks and branches of olive trees, occasionally on apple, plum, Oregon oak trees, *Quercus garryana*, and the poison oak, *Rhus diversilobia*, and on grapevines.



A—male, *H. severini* n. sp.; B—female specimen, same; C—eggs of same on branches of olive trees.

All photography by H. H. P. Severin.

MORAVIAN INFLUENCE ON INDIAN LIFE IN THE TUSCARAWAS MISSIONS, 1772 - 1777[1]

AUGUST C. MAHR,
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By the middle of the 18th century, the Indians in the North American East had learned to realize that the white man's real intention was conquest of their territory itself, rather than concessions within it. By a shrewd alternation of military and diplomatic action they had been deprived of more and more of their ancestral hunting-grounds and arable fields. Belatedly aware that a timely alliance between the Iroquois and Algonquin nations might have expelled the intruders, they now saw that a gradual retreat toward the west was the only course open to the Indians, did they wish to maintain their national and tribal identities.

The Iroquois family of nations, who had long been bound together in a powerful federation, were less inclined to yield to the white pressure than were the Algonkian Indians in general, and the Lenni Lenapi, in particular, who had always been less politically minded and, therefore, less effectively organized than their more aggressive rivals. Eventually, the greater part of the Lenni Lenapi, better known as Delawares, left their land in the Delaware River basin and resettled on territory ceded to them by the Wyandottes. It roughly covered what is today the eastern half of the State of Ohio (1). Its boundaries ran, as follows: from the confluence of the Big Beaver with the Ohio up the Beaver and Mahoning Rivers; down the Cuyahoga to Lake Erie; then, along Lake Erie, westward to the mouth of the Sandusky; from there, in a generally southward direction, first to the headwaters of the Sandusky, and then, along a line slightly east of, and parallel with, the Olentangy and Scioto, to the headwaters of the Hocking River; down the Hocking to the Ohio; and finally up the Ohio, back to its confluence with the Big Beaver.

Among the part of the Lenni Lanapi nation, who had not left their old homeland, in the Delaware River basin, the Moravian Brotherhood had been successfully missionizing ever since the founding of the first Moravian settlements in Pennsylvania: Nazareth, in 1738; and Bethlehem, in 1741, even today the home of the Moravian Church in America (2). These two mission towns, and a few more, which had been settled and occupied by white brethren and sisters, attained permanence. Such mission towns, however, as had been built under the guidance of white Moravians by and for Indian converts, had eventually to be abandoned under the same political pressure that had previously driven about half of the Lenni Lenapi Nation into the forest lands across the Ohio River. First, the two mission posts on the Susquehanna, Friedenshütten and Schechschequanünk, had to be abandoned for Langundoutenünk (Friedensstadt), on the Beaver River (3); and shortly afterwards the converts and their Missionaries, from all three stations, again found themselves on the road to better promise; this time, to the Tuscarawas Valley, where the land for new settlements had been offered the Moravian missionaries and their flock of Indian converts by Netawatwes, the Great Chief of the Lenni Lenapi nation (4).

With the vision of a good ruler, Netawatwes had long realized the motivating force toward a better life, both economical and social, of morals such as taught in the gospel of Christ. Hence, he decided, with the consent of his Grand Council, to invite the Moravians to establish their teachings and mode of living among his

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[1] Paper read before the Anthropology Section of the Ohio Academy of Science at the annual meeting, in May, 1948, at Toledo, Ohio. It summarizes part of the research work done by Dr. Mahr for The Ohio State Archaeological and Historical Society in connection with the restoration of the Moravian Mission town of Schönbrunn. The Society contemplates a detailed publication of these studies when completed.

Lenni Lenapi (5) whom he knew to be too undisciplined and unprincipled to withstand unaided the various temptations introduced by the white man. The worst of them, rum, had long been undermining the physical and moral resistance not only of his own people but of other Indians likewise (6).

In August, 1772, David Zeisberger, John Ettwein, and John Heckewaelder arrived in the Muskingum basin and forthwith laid out, on the Tuscarawas River, about two miles south of the present town of New Philadelphia, the village of Schönbrunn (7); and, in the same year, Gnadenhütten, 10 miles downstream from Schönbrunn (8). Through five years, these two settlements grew and prospered, both spiritually and economically, until, in 1777, they were seriously threatened by both of the conflicting parties engaged in the Revolutionary War, and had to be abandoned (9). In 1776, a third Indian mission town, named Lichtenau, had been founded in the immediate neighborhood of Netawatwes' capital (10), only to share the fate of Schönbrunn and Gnadenhütten a few years afterwards (11). It is an uncontested fact that the Lenni Lenapi chiefs did their utmost to keep neutral in the Revolutionary War (12), as well as they had in Dunmore's War, in 1774. In the latter conflict their War Captain, White Eyes, rather than Chief Netawatwes, had prevented the surging waves of Indian hatred from wiping out the Moravian mission towns and their Christian Indians together with the white teachers. True, it had been Netawatwes' initiative that had enabled the Moravians to settle in the Lenni Lenapi territory, but it was White Eyes' firmness of purpose and character that, in those days, not only averted a catastrophe (13) but also brought David Zeisberger's religious and political plan of "a Christian Indian state in the midst of the aboriginal domain" close to being realized (14). Its eventual failure was brought about, in the course of the Revolutionary War, by forces beyond the control of either the Lenni Lenapi Chiefs or the wisdom of Zeisberger. At the close of the war it was evident that the dynamic force of the white man's westward surge had forever sealed the fate of Zeisberger's and White Eyes' static concept of a Christian Indian state with legally guaranteed territorial boundaries (15).

About 1870, Edmund de Schweinitz, Zeisberger's Moravian biographer, wrote these lines:

> ". . . along the Tuscarawas and the Walhonding, the Muskingum, Hockhocking, and Scioto, not a solitary Indian lodge remains; from the waters of Lake Erie to the bluffs of the "Beautiful River," not a remnant of the Lenni Lenapi can be found. A great and teeming commonwealth of Americans is in the place of that home which White Eyes would have given to his people. Such was the will of God." (16).

This concluding phrase, coming from a true historian, is just another way of saying that the success of the Christian Indian state plan might have changed the entire course of history, not only on this continent but, indirectly, in Europe likewise.

Prior to his coming to the Muskingum basin Zeisberger had long acquired a profound insight into Indian life and mentality (17). It was in close co-operation with Bishop Ettwein, a remarkable organizer and executive, that the guiding principles for the Moravian mission work among the Lenni Lenapi were worked out (18).

As a foundation they laid down a code of statutes binding for all Indians who wished to live as Moravian Christians. If, after a period of probation, the applicants found that they could not meet the stipulations of these statutes; or, if the Missionaries saw, in the character of the applicant, certain flaws unlikely to disappear, residence in the Moravian community was denied (19).

This code contains 19 articles, some of which enjoin the Indians to do, or not to do, something which, in some respect, was foreign to them. Other articles lay down, as binding rules, certain moral tenets which, previously, it had been at their choice to observe or to ignore. Others took care of ruinous habits acquired from contacts with whites, for instance, use of strong liquor, and unsound trading practices.

The first three of these articles are divine laws, corresponding to the first, third and fourth Commandments of the Decalogue; that is, exclusive worship of the One True God, and His incarnation in Jesus Christ; observance of the Lord's Day; and Honor to Father and Mother, with a pledge to provide for their old age. All three of these injunctions were new to the Lenni Lenapi who, like other Indian nations, had no concept of religious dogma, although they had held some hazy notions which, in part, had come to them from tribal tradition, but, in greater part, through much polluted channels, from old-time contacts with other missions, mainly Roman Catholic. Nor had they been under any direct obligation to support their old people although it was usually done (20).

Article 4 makes the reception into the Moravian community dependent on the consent of the Missionaries and an inquisition held by the Helpers.

Article 5 prohibits contacts with "thieves, murderers, whoremongers, adulterers, or drunkards." While, as a rule, the heathen Lenni Lenapi were not given to stealing, or murder, among themselves (21), they were highly promiscuous; committed adultery, with complete impunity for both men and women, married or unmarried (22); and reveled in alcoholic orgies that often involved an entire community, as it is attested by the Rev. David McClure, not a Moravian, on the occasion of his visit, in 1772, to Gekelemukpechünk, the capital of Netawatwes (23).

This native propensity to drunkenness caused the formulation, and relentless inforcement, of Article 13: "We will not admit rum or any other intoxicating liquor into our towns. If strangers or traders bring intoxicating liquor, the helpers shall take it form them, and not restore it until the owners are ready to leave the place." May it be said that the liquor traffic, to a great extent, was in the hands of Indian women (24) who, among numerous tribes, had the traditional right to sell, or trade off, most of what they or their husbands produced (25).

Intricately tied up with the drinking of the Lenni Lenapi were their "dances" as well as their "sacrifices, heathenish festivals or games," forbidden, for Christain Indians, by Article 6. Gambling, by means of peachstones used in the manner of dice, and also with imported playing-cards, was, next to drinking and sexual promiscuity, the most ruinous diversion of the Lenni Lenapi (26). These endemic vices were a matter of vital concern to some of the chiefs. Netawatwes repeatedly tried to stop the evil practices but never succeeded for any length of time (27).

The Lenni Lenapi were also notorious for the looseness of their marriage bonds (28). Polygamy, although rarely practiced as such (29), frequently resulted in cases where a husband, or wife, had become tired of their partner and had simply left to live with somebody else. The children then followed the mother since they were considered her property. Those who were grown up could follow the father if they so wished (30). Hence, Article 12 was formulated, as follows: "A man shall have but one wife—shall love her and provide for her and his children. A woman shall have but one husband, be obedient to him, care for her children, and be cleanly in all things." At times, the Mission authorities found themselves hard put to reconcile their converts' married status with the Christian view on matrimony. After lengthy debates among the authorities of the Moravian Church, at Bethlehem, Bishop Ettwein seems to have tacitly agreed that Indians who, at the time of their reception into the Christian community, had in good faith married two women, should love and honor both wives (31).

Since, in accordance with tribal custom, marriageable adolescents were free to marry whomever they wished, even against the will of their parents (32) article 16, of the code, commanded "young persons" not to "marry without the consent of their parents and the minister;" this rule was to prevent unbaptized persons from being brought into baptized families, and thus create confusion (33). Intermarriage with white persons was in no way opposed; Bishop Ettwein, on the contrary, is on record for having recommended that a certain young missionary marry "a pretty Indian Sister," prior to his being placed in charge of a mission station (34). That the Lenni Lenapi had no race prejudice either is evident from cases where, in heathen communities, Negro slaves owned by Indians married within the tribe (35); and from other cases where Indian women, who generally were fond of white children, ran after white men until they had attained their purpose (36).

The last of the nineteen articles was adopted in later years, during the Revolutionary War (37). It commands the Christian Indians "not to go to war," nor to "buy anything of warriors which had been taken in war." It was the acid test of their religious faith, for it certainly took as much courage to forsake their warrior's status in the face of tribal derision, as it required on the part of the missionaries to make such a demand of Indian males. The amazing fact remains that the law was obeyed by the majority of the faithful.

One of the fatal shortcomings of the Indians and, particularly, the Lenni Lenapi, was their failure to decide upon a definite change from the life of the roaming hunter to the stationary existence of the farmer and cattle-raiser. Netawatwes and some of his councillors were well aware of the racial suicide forboded by such half-hearted wavering between the two economic principles (38). It seemed impossible to break the old habit of moving from one place to the other whenever their hunting grounds of the region became depleted, as each hunter shot from 50 to 150 deer a year; or merely, because fire-wood became scarce in the immediate neighborhood of their village (39). They simply left for another location, shiftlessly abandoning the corn crops their women had planted in the fields.

His desire to have the Moravian influence near at hand, and to make his people benefit from their example, was one of Netawatwes' principal motives for planting their missions in the Tuscarawas valley. Naturally, the missionaries were confronted with the same basic difficulties as was the Chief, but they succeeded where Netawatwes had failed, because they attacked the evil from its roots: faulty division of labor, and lack of any discipline whatsoever. Article 9 of the Moravian mission code reads, as follows: "We will obey our teachers and the helpers who are appointed to preserve order in our meetings, in the towns, and fields." The Missionaries had long realized that obedience was the primary requirement, if they expected the Indian men to do any work in the fields; chores, which theretofore had exclusively been done by the women. The men primarily were hunters and warriors; occasionally they put up a house or a fence, but everything else was left to the women, who tilled the soil; planted the seed; harvested the crops; gathered fire-wood; carried water; prepared the meals and sewed the clothing for the family; gathered the wild hemp for their making of carrying-girths; gathered rushes, along with the herbs and roots to dye them with; weaved the dyed rushes into mats; dressed deer-skins and made them into leggings and moccassins. On top of that, they bore the main labor load during the sugar-boiling season, in February and March, and were lucky if their husbands, in the predeeding winter months, had seen fit to carve enough wooden bowls and troughs to hold the maple-sap. Occasionally, a man would take a hand in keeping the sap from boiling over, while, as a rule, the men, during the sugar-season, were roaming the forests, hunting, in order to provide meat for immediate consumption, as well as for drying and storing it, to last through the summer.

John Heckewaelder, more objective than Zeisberger as a critic of Indian sociology, defends the Lenni Lenapi male against the opprobrium of shiftless loafing and pleasure-seeking. He argues that the women's "hard and difficult employments are periodical and of short duration, while their husbands' labors are constant and severe in the extreme." Since on the husband's "exertions as a hunter, their existence depends," "he must keep his limbs as supple as he can, he must avoid hard labor as much as possible." Hence, he cannot think of taking "upon himself a part of his wife's duty, in addition to his own," or "he must necessarily sink under the load, and, of course, his family must suffer with him (40)."

Whatever the merits and demerits of the two sexes, they were the results of an unbalanced division of labor, typical of a transitional economy that no longer rested exclusively on hunting and gathering, but had not yet reached the full stage of farming and cattle raising.

It was the aim of the Moravian mission system to shift the economic balance of the Lenni Lenapi definitely to farming, by means of a well considered division of labor between men and women. The men were to restrict their hunting excursions to a minimum, both in extent and frequency (41), while the women's burden was to be lightened by making their former activities in the fields joint enterprises of both sexes, in the form of community labor (42). Community labor was also demanded of the men when public structures had to be put up, such as a church, or a school house, or fences around the town and fields; or when the increase of the convert population called for the building of a number of new houses. In such cases, the women as a group provided food for the men as a group (43). The missionaries gave much thought to the even spreading of labor and leisure over the hours of the day, as well as over the whole year. The real secret of their success was their wisely calculated long-term planning. They decided what had to be done, at what season of the year, and with how many workers available over how long a period (44). In order to assure the desired results, Article 17 was drawn up, as follows: "Whenever the stewards or helpers appoint a time to make fences or to perform other work for the public good, we will assist and do as we are bid."

There is no evidence from the mission reports that the local administration's economic efforts were ever frustrated by Indian reluctance to work, let alone, defiance. On the contrary, there are numerous entries testifying to both the excellent planning of community projects and their amazingly speedy completion (45).

One of the first things to be done, once that the site of a new mission station had been selected, was the laying out of the prospective town in the manner which the Moravians called "regular" and which they followed in all their settlements. The basic plan pattern is the same in every Moravian mission town: namely, an aligning of the houses, along cross streets, in town blocks of equal size, symmetrically arranged right and left of a main street functioning as the symmetry axis, with the Church on a key point of the symmetry system.

This was in fundamental contrast (as coercive as it was intentional) to the Lenni Lenapi's native notions of settlement. They had been in the habit of building their houses as close to, or as remote from, each other's as they chose; and of abandoning their lodgings whenever they had a mind to, and, with them, their cultivated fields, provided they had cared to cultivate any (46). Those at Schönbrunn, Gnadenhütten, and the other missions, found themselves fitted in a framework of geometric boundaries, as equal parts of a structural unity, in both the physical and social sense; a structure, not merely tangibly static but also inspiringly dynamic, in that it almost automatically mobilized all its individual members for the service of the whole.

The plausibility of this system, and of the methods sustaining it, not only captivated the Indian converts living by it, but it also caught the imagination of those among the heathen Lenni Lenapi, who had eyes to see and ears to hear. They realized that the magic of form, such as embodied in Schönbrunn and Gnadenhütten, might merit acquisition by imitating its outer shape, so as to serve as an arcanum against the forces of evil, which were breaking up their national life from within. In 1775, the heathen Lenni Lenapi laid out for themselves a brand-new town on which Zeisberger comments in these words:

> "Their new town has been laid out and staked off in the form of a cross-street, lying along the Muskingum, the design having been copied from us. . . . Each tribe, clan and nation is to have its own street."

A few lines below he points out their faulty approach, as follows:

> "As they have much work and there are many people, who, however, hinder each other because they do not know how to portion out their tasks, our brethren, upon their request, gave them good advice and told them how we proceeded in our Towns, which pleased them so that they declared they would follow our example." (47).

Needless to say, the project failed miserably.

In order to assure a continued success of their mission plan, the missionaries paid great attention to a proper upbringing and adequate schooling of the converts' children (48). Schönbrunn and Gnadenhütten as well as the other mission towns had schools in which religion, reading, writing, and a little arithmetic were taught in the native language. The textbooks were the work of Zeisberger who completely mastered the Lenni Lenapi dialect; both he and Heckewaelder conducted the school at Schönbrunn (49). Regular attendance was demanded, and the parents, especially the mothers, were exhorted to train their children away from idleness (50). Since the girls had always been taught to work anyway, this admonition mainly applied to the boys who, under native conditions, were never urged to do anything they did not wish to do (51). In the training of their children, even the Christian Indians appear to have been rather negligent, for again and again new admonitions had to be issued to the parents to take better care of their children and keep them clean and busy.

In general, the missionaries interfered as little as possible with their converts' ancestral customs. Of course, certain habits in dress and ornamentation had to be curbed (52). Christian Indians were not expected to wear nose-rings; or grow a scalp-lock (53) and pluck out the rest of their hair; or to use body and face paint; or tattoo their faces and bodies (54); or hang silver ornaments in their hair, and silken ribbons on their clothing, as it was a fashion with the women, and to some extent also with the men. Such were heathenish customs "not suitable for church members," as Zeisberger puts it (55).

The range of this article does not permit to present more reasons why it is to be regretted, that the course of history had decided against Zeisberger's plan for a Central Christian Indian State.

Not in terms of regret but rather in the form of constructive, although belated, advice did Thomas Jefferson enjoin the Indian chiefs of his day, among them several Lenni Lenapi, in repeated letters, to ward off the extinction of their race by doing essentially what the Moravians had set out to teach them. In a letter, undated, but probably of 1808, to the Lenni Lenapi War Captain Hendrick, Jefferson wrote these words:

> ". . . if you wish to increase your numbers you must give up the deer and buffalo, live in peace; and cultivate the earth. You see then, my children, that it depends on yourselves alone to become a numerous and great people. Let me entreat you, therefore, on the lands now given you to begin to give every man a farm; let him enclose it, cultivate it, build a warm house on it, and when he dies, let it belong to his wife and children after him. Nothing is so easy as to learn to cultivate the earth; all your women understand it, and to make it easier, we are always ready to teach you how to make ploughs, hoes, and necessary utensils. If the men will take the labor of the earth from the women they will learn to spin and weave and to clothe their families. In this way you will also raise many children, you will double your numbers every twenty years, and soon fill the lands your friends have given you, and your children will never be tempted to sell the spot on which they have been born, raised, have labored and called

their own. When once you have property, you will want laws and magistrates to protect your property and persons, and to punish those among you who commit crimes. You will find that our laws are good for this purpose; you will wish to live under them, you will unite yourselves with us, join in our great councils and form one people with us, and we shall all be Americans; you will mix with us by marriage, your blood will run in our veins, and will spread with us over this great island." (56).

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NOTES

(1) *HH*, p. 84.
(2) *HN*, p. 113 f.
(3) *Ibid.*, p. 234 ff.
(4) *Ibid.*, p. 238 ff.
(5) *Ibid.*, p. 229.
(6) *McCD*, pp. 63–66; *HN*, p. 324.
(7) *HN*, p. 238 ff.
(8) *Ibid.*, p. 241 ff.
(9) *Ibid.*, p. 276.
(10) *Ibid.*, p. 261.
(11) *Ibid.*, p. 330.
(12) *HN*, chap. XVIII; *deSchZ*, chapters XXVII and XXVIII.
(13) *SD 7* (Feb.–May, 1774); *deSchZ*, pp. 413–419.
(14) *deSchZ*, p. 413.
(15) *Ibid.*, p. 419.
(16) *Ibid.*, p. 419.
(17) *Ibid.*, chapters VI-XX.
(18) *Ibid.*, chap. XXI.
(19) *HN*, p. 238 ff; *DeSchZ*, p. 378 f.
(20) *ZH*, p. 123 f.
(21) *Ibid.*, p. 123.
(22) *Ibid.*, p. 20 f.
(23) *McCD*, pp. 73–80.
(24) *ZH*, p. 117.
(25) *Ibid.*, p. 16; HH, p. 158.
(26) *Ibid.*, p. 118 f.
(27) *Ibid.*, p. 117.
(28) *Ibid.*, pp. 20 f., 82 f.
(29) *Ibid.*, p. 81.
(30) *Ibid.*, p. 99.
(31) *HJE*, p. 107.
(32) *ZH*, p. 79.
(33) *HJE*, p. 109.
(34) *Ibid.*, p. 105 & n.
(35) *ZH*, p. 124.
(36) *Ibid.*, p. 141.
(37) *HN*, p. 240.
(38) *SD 1* (May 7, 1772).
(39) *ZH*, pp. 14, 87.
(40) *HH*, chap. XVI.
(41) *ZH*, p. 14.
(42) *SD 11* (June 16, 1775), *GnD* (June 15, 1773), *et al.*
(43) *GnD* (Aug. 23, 1773).
(44) *SD 3* (Jan. 24, 1773); *SD 7* (April 11, 1774).
(45) *GnD* (Aug.–Sep., 1773); *SD 5* (Sep.–Oct., 1773).
(46) *ZH*, p. 87.
(47) *SD 10* (April 7, 1775).
(48) *HJE*, p. 113; *SD 3* (Dec. 22, 1772); *et al.*
(49) *Conf Min* (Aug. 17, 1772); *SD 12* (Dec. 4, 1775).
(50) *SD 10* (April 27, 1775).
(51) *ZH*, p. 16.
(52) *SD 12* (Jan. 15, 1776).
(53) *TMHS*, Vol. I, p. 349.
(54) *HH*, p. 206.
(55) See note (52).
(56) *CJ*, p. 508.

MISSISSIPPIAN DISCONFORMITY AND COMPACTION

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One of the best examples of a disconformity in Ohio is displayed in a railroad cut about one-half mile northeast of Marshallville in Chippewa Township. This disconformity has been mentioned by Conrey.[1] The outcrop shows a horizontal mass of Mississippian sandstone of the Waverly series, and above it and dipping away from it on all sides, the lower portion of the Pottsville formation of the Pennsylvanian system. What formation of the Waverly series is represented in the exposure has not been satisfactorily determined. It is probably the Logan sandstone formation. It is believed by some geologists that the member may be the Black Hand sandstone of the Cuyahoga formation. The thick-bedded sandstone with occasional thin beds of shale resembles to some degree the Black Hand sandstone in its northerly extension in Ohio.

The Pottsville formation in the exposures near Marshallville consists of rather coarse-grained sandstone with occasional small white quartz pebbles from one-eighth to one-half inch in diameter. It is not as conglomeratic as is usual of the basal Pottsville. The jointing is irregular and varies in color from gray to yellow to red. It contains the carbonaceous remains of plants. The basal sandstone grades upward into coal-black laminated shales containing concretions. In this shale are occasional sandy strata. Glacial till covers the entire area.

As one walks along the railroad in a northeasterly direction from Marshallville, the first buried hill makes its appearance. Here the massive sandstone beds of the Waverly are flanked for the most part by shale and some sandstone strata which dip away in all directions, at first steeply and diminishing with distance. Farther on, the basal beds of the Pottsville rise to form an arch which appears above the track level in the cut. The buried hill of Waverly sandstone is not exposed but the evidence of its existence is indicated by the dome-like structure of the basal Pottsville. Farther on, the railroad cuts across the top of the largest of the buried sandstone hills (Figs. 1 and 2). The Pottsville beds dip away in all directions, first steeply and gradually flattening out with distance and ultimately becoming horizontal.

Before the advent of the glaciers in Pleistocene time, the Pennsylvanian formations were eroded from the top of the buried hills but were preserved in the basins between.

In the long interval which elapsed after the Mississippian beds were laid down a great amount of erosion must have taken place. Over a large part of Ohio, the upper Mississippian was completely removed and in the northeastern part of the state, a large part of the Waverly series of lower Mississippian age was eroded. In some places in northeastern Ohio, so much of the Waverly series was eroded that the basal Pottsville beds lie not far above the Berea sandstone. Throughout Ohio and beyond there is evidence of widespread erosion following the Mississippian and prior to the deposition of the Pennsylvanian formations.

A study of the exposures near Marshallville indicates that the Mississippian sandstone was weathered during the interval represented by the disconformity. Incorporated in the beds at the base of the Pottsville formation are sandstone fragments derived from the Waverly sandstone. These are angular for the most part but show the effects of having been moved by waves and currents. The contact between the Pottsville and Waverly is sharp. The basal Pottsville shales and sandstone flatten out where they project over the top of the buried hill.

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[1] Conrey, G. W., Geology of Wayne County, Geological Survey of Ohio, Bulletin 24, 1924, page 92.

It is evident that a rough topography resulted from the erosion of the Mississippian formations before the advent of the Pottsville sea. A hilly topography was invaded by an encroaching Pennsylvanian sea. That the hills were buried beneath Pennsylvanian sediments and not removed by wave and current erosion may indicate that the land sank at such a rate that marine erosion did not have time to bevel the surface.

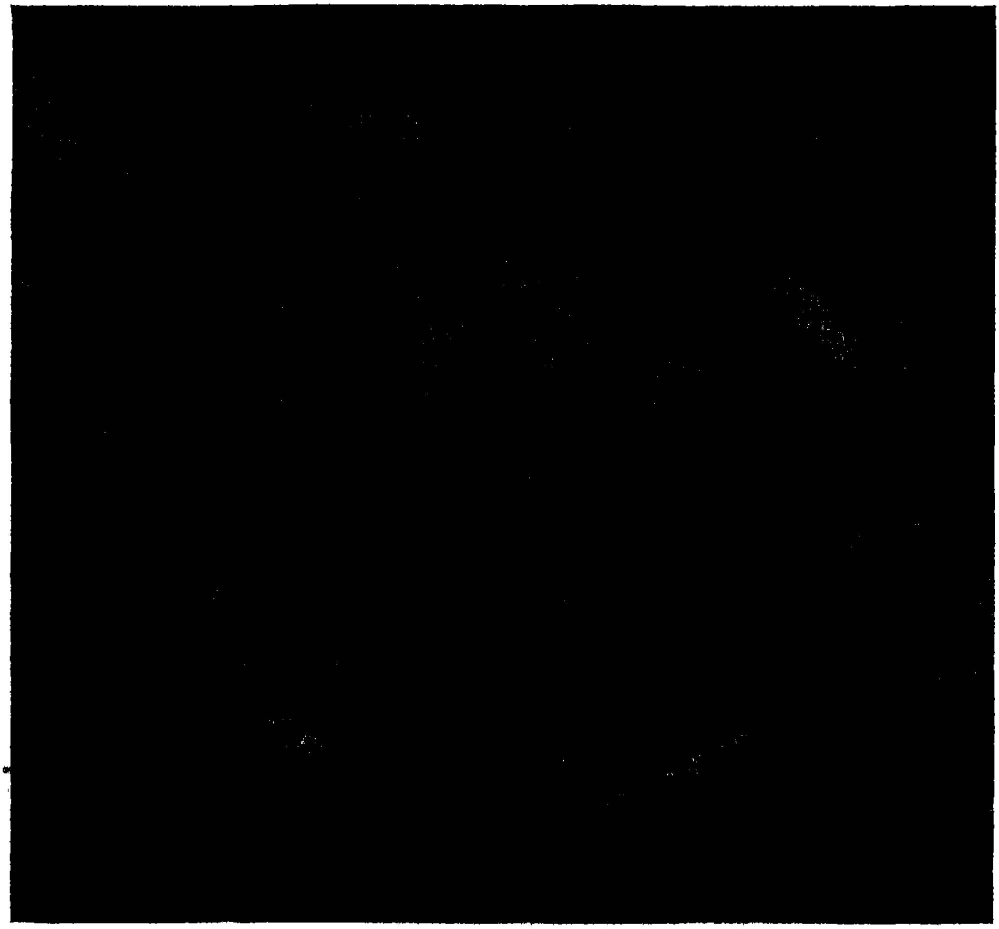

FIG. 1. A buried hill composed of horizontally lying Waverly sandstone and the inclined, overlapping Pottsville strata. Note the decrease in dip of the Pottsville beds from the hill.

The irregularity of the contact between the Mississippian and Pennsylvanian systems can be appreciated when the variation in elevation of the contact is obtained over large areas. In places, differences of more than 150 feet or more occur within short distances. At one locality in Wayne County the contact is 1060 feet above sea level and five and one-half miles to the southwest the conglomerate in the Pottsville formation at the base of the Pennsylvanian rests on the Waverly surface at an elevation of 880 feet above tide. Many other striking illustrations of the magnitude of this unconformity in Ohio could be given. As the Pennsylvanian seas covered the rough Waverly surface, the oldest members of the Pennsylvanian system were deposited in basins and channels.

According to Twenhofel,[2] deformation caused by compaction results from the settling of sediments over any rigid body. This may be a buried hill, a reef or a sand or gravel lens. Compaction arises from the expulsion of water, closer packing or new combinations of sediments. It is believed to be negligible in sands and coarser clastics and is most important in fine-grained sediments such as clays, silts and calcareous muds. Some marls and clays are composed of as much as 70% water and many fine-grained sediments contain more than 50%. Much of this water is expelled with a corresponding reduction in volume. Compaction due to

FIG. 2. Section of the Waverly sandstone. The entire width of the exposure in the railroad cut is about 300 feet.

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[2] Twenhofel, W. H., Principles of Sedimentation, pp. 582-583.

crystallization and packing is also noteworthy. However, the expulsion of water is by far the most important factor. Fine-grained sediments deposited over and around reefs and lenses of sand or coarse clastics may experience compaction of 50% or more. Strata passing over the non-compactible Waverly sandstone hills would become arched into domes and anticlines, depending on the slopes of the buried features.

The fine-grained sediments would be washed from the high places into the basins. There can be subaqueous sliding from the steeper slopes into the basins. Twenhofel points out that compaction and settling proceed simultaneously with deposition, maintaining some slope until the high places have been completely buried and the overlying formations could be warped through considerable thicknesses. The buried hill or rigid body could thus be reflected through considerable thicknesses of sediment as folds or domes.

The buried Waverly surface with its hills would be favorable for the development of structures of compaction origin. They have been noted in the midcontinent and other regions in the drilling for oil. The marked dip of the Pottsville beds in all directions from the buried hills and the dome and anticlinal structure above them may be accounted for by compaction.

GUANIDINE FERRIDEHEMOGLOBIN AND THE CARBIMID STRUCTURE OF "CYANAMIDE"

THE RELATIONSHIP OF CHEMICAL STRUCTURE TO CHOLINERGIC ACTIVITY

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The capability of combination of ferrihemoglobin with the majority of known hydroacid anions suggested that this type of combination was due to the comparatively small ionic diameter of the latter with their consequent ability to penetrate the interstices of the porphyrin ring and come within sufficient proximity of the 3^2 electronic orbit of the iron atom to permit polar covalent combination. [1, 2, 3] This capacity would be facilitated by a distortion of the octahedral iron-porphyrin lattice whereby at least one of these interstices is widened. Such a lattice distortion for ferrihemoglobin has been postulated by Coryell and Stitt[4] who regard combinations of the ferrideheme type as exemplifying a heptacovalency of the iron. Since ferrideheme combinations of ferriheme and the ferrihemochromogens are rare while those of ferrihemoglobin are frequent, it is reasonable to assume a lattice distoration in the last case through its iminazolyl coordination[5] (Fig. 2). Heptacovalency would then account for combination with any of the ordinary anions. This, however, does not occur; ferrideheme formation potentiality is limited to a specific group; the hydroacid anions. With the discovery of O-benzoic sulfinide ferridehemoglobin[2]—the anion in this case being relatively large—it became apparent that size of the hydroacid anion was not the conditioning factor and search was made for other chemical common property characteristics of this class of anions. Stereochemical representation of the O-benzoic sulfinide radicle showed an acute polar tenaille. Since an acute tenaille would permit approximation of the polar group to the 3^2 orbit of the iron, the other ferridedheme formers were examined in this regard. Acute polar tenailles were demonstrable for all with the single exception of cyanamide as depicted by the ordinarily ascribed carbamonitrile configuration (Fig. 3).

However this configuration is at variance with the low dipole moment of cyanamide ($\mu_{20^\circ C} = 3.8$ D)[6] and the Raman spectrum suggests that some of the material in solution is in the carbimid form.[7] This form, rendered in Fig. 4 is isosteric with carbon dioxide and its ionized form would have two acute tenailles. Such a representation, if correct, would indicate that cyanamide is an anammonide of guanidine rather than (as the carbamonitrile) an anhydride of urea. There are some physiologic and pharmacologic bases for regarding the former relationship to exist. (1) Administration of arginine to cystinuric individuals results in the excretion of cyanamide.] (2) Cyanamide is available for the *in vitro* synthesis of creatinine.[9] (3) Cyanamide and guanidine are both cholinergic drugs; the fibrillary somatic twitching of cyanamide intoxication being abolished by atropine[10] as is the same feature of guanidine poisoning.[11] Because of the definitely close pharmacologic, and a possible chemical relationship of the two substances one might anticipate ferrideheme formation on the part of a solution of guanidine the aresonant form of which has an acute polar tenaille (the ionizable imino group). But since the bulk of such a solution would consist of the resonating guanidinium ion[12] a large molar excess should be necessary to demonstrate such combination.

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EXPERIMENTAL

Ferrihemoglobin solutions were prepared by the treatment of laked, washed human erythrocytes with (A) ferricyanide solution, (B) azochloramide or (C) saturated aqueous iodine. All pigment solutions were then diluted to a ferrihemoglobin concentration of 0.4 millimolar. Samples of each solution were brought

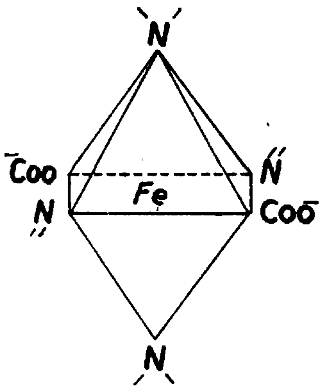

FIG. 1

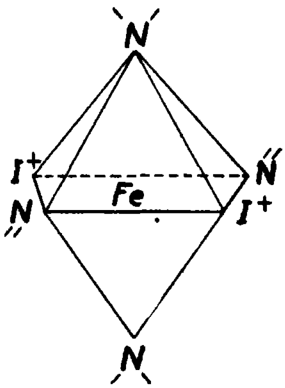

FIG. 2

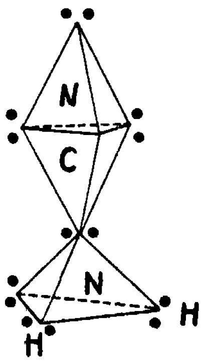

FIG. 3

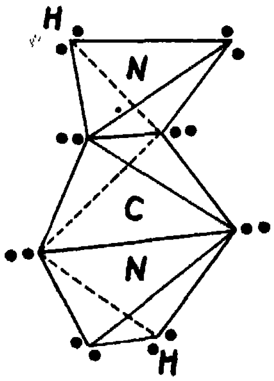

FIG. 4

FIG. 1. Stereochemical representation of axially symmetric octohedral hexagonal ferriheme pattern in which the carboxyls are coordinated in the 4° electronic orbit of the iron without distortion of the porphyrin lattice.

FIG. 2. Asymmetric porphyrin lattice of ferrihemoglobin. Distortion of one or more of the octohedral facets is brought about by coordination with the quarternary iminazolyl nitrogen of the globin histidine. By this agency one or more interstices in the 4° coordination shell is widened permitting polar covalent linkage with the iron in the 3^2 electronic orbit by anions or negative radicles with an acute polar tenaille.

FIG. 3. Carbamonitrile structure of cyanamide showing two obtuse polar tenailles on the same nitrogen atom. For purposes of representation in this and Fig. 4, the molecule is depicted in its undissociated state; the tenailles being in polar covalency with hydrogen.

FIG. 4. Carbimid structure of cyanamide; a symmetrical molecule with two acute polar tenailles each of which is on a separate nitrogen atom.

to varying guanidine concentrations ranging from 0.1 to 2.0 Molar by the addition of guanidine hydrochloride. After various intervals the reaction mixtures were subjected to spectroscopic examination.

Concentrations of guanidine less than 0.3 M are without effect on the color or spectroscopic features of ferrihemoglobin solution. Concentrations between 0.3 and 1 M produce a gradual color change from brownish to scarlet and the ferrihemoglobin absorption band in the red region of the spectrum is replaced by a diffuse single band with indefinite limits ranging from about 5400 to 5900 A°.

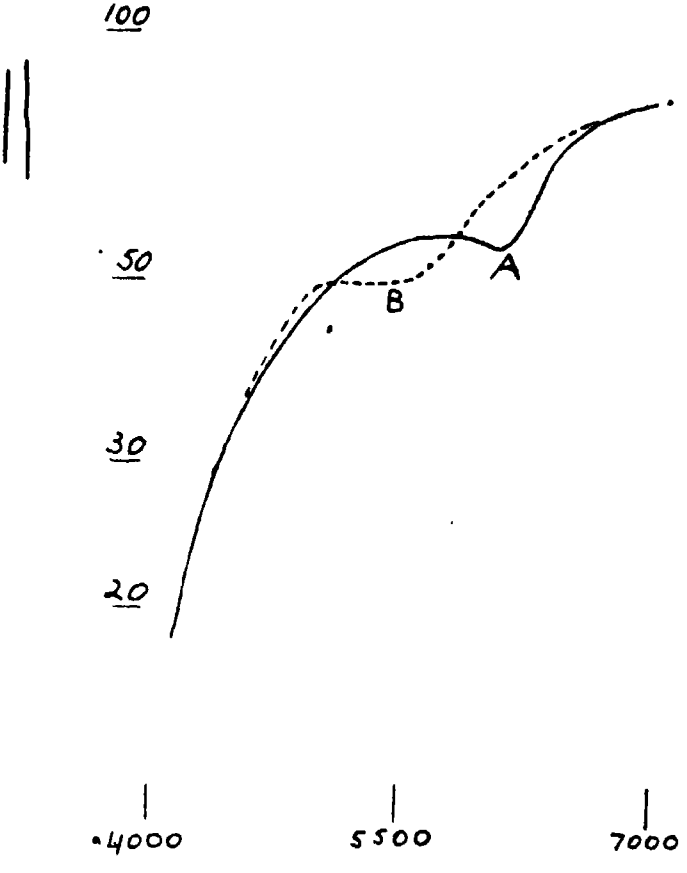

FIG. 5. The Effect of Sulfhydryl on the Spectrophotometric Absorption Curve of Lithium Ferriheme. The ordinates represent percentage transmissions and the abcissae, wavelength in decimicrons. Curve A shows the absorption of lithium ferriheme solution while curve B shows the absortion of an identical solution containing a molar equivalent of cysteine. The shift in spectral absorption which accompanies ferrideheme formation is qualitatively similar to that caused by the addition of guanidine or cyanamide to ferriheme and the direction and magnitude of this shift is best explained on the basis of polar covalent combination in the 3^3 electronic orbit of the iron. Such inner orbital covalency may be an example of a theoretically possible interorbital type of resonating structure.

(This is the region in which all of the ferridehemoglobins exhibit their single absorption band). Guanidine concentrations above 1 M cause a rapid but evanescent appearance of this band after which denaturation occurs. Apparently guanidine reacts with ferrihemoglobin in a twofold manner; by ferrihemoglobin formation and denaturation, the former being a zone reaction because of the intrusion of the latter. By stratification of a 0.4 M ferrihemoglobin solution upon a saturated guanidine hydrochloride solution in a test tube, a ring color reaction gradually develops within the ferrihemoglobin stratum and at the time of its greatest clarity and breadth (about 10 hours after stratification) is amenable to spectroscopic examination, upon which it is found to be practically indistinguishable from cyanamide ferridehemoglobin.

The experiments were controlled by testing the effect of guanidine on the pH of ferrihemoglobin solutions. This was deemed advisable even though the colored reaction product bore no spectroscopic resemblance to ferrihemoglobin hydroxide because the similarity of the guanidine and cyanamide-ferrihemoglobin reaction products might give rise to the suspicion that guanidine was converted to cyanamide during the course of the reaction. While the possibility of such a conversion is highly remote in this instance (on purely chemical grounds) it is ruled out by the absence of pH change in the reaction mixture as any such change must be accompanied by the liberation of ammonia. Cyanamide in 5 Molar concentration does not denature ferrihemoglobin while denaturation is evident in the presence of one-tenth this molar concentration of guanidine.

DISCUSSION

It appears probable that the colored reaction products of cyanamide and ferrihemoglobin on the one hand and of guanidine and ferrihemoglobin on the other, while not identical have a similarity conditioned by that of their respective prosthetic groups. An actual similarity of these groups would be possible only on the assignment of the carbimid structure to cyanamide.

The manner in which ferrideheme formation potentiality governs the cholinergic activity of a compound is not clear though, with the exception of acetylcholine (which might, in vivo, assume a transitional resonant state) this feature is so common to cholinergic drugs that the property is difficult to regard as an artefact. It has been suggested that cholinesterase owes its enzymatic activity to a transitional element prosthetic nucleus.[13] This might explain the role of the acute polar tenaille in the anti-esterase cholinergics but it does not explain histamine, guanidine or pilocarpine activity unless it is assumed that the cell receptors, themselves, are also heme (or other transitional element prosthetic nucleus) conditioned. In this connection it is curious that those three amino-acids exclusively, which posses acute tenailles; arginine, histidine and cysteine, can block histamine action presumably by usurping its destined position in or on the receptor substance.[14] The formation of a ferrideheme by cysteine and the soluble iron-porphyrin derivative, lithium ferriheme[15] is shown by the comparative spectrophotometric curves in Fig. 5. In this case the determinant role of the acute polar tenaille (sulfhydryl) and the subsidiary role of general molecular species is further exemplified.

Whether or not the hypothesis, that polar covalent linkage in the juxtaperipheral orbit of a transitional element prosthetic nucleus, conditions cholinergic activity, should prove to be correct it will nevertheless have been a useful one. As a single example of this utility it may readily explain on a structural basis the verified histaminic effect of colloidal silica[16] which Habeeb[17] regards as the important pathodynamic feature of human silicosis. Any particle of colloidal silica, whether from quartz, cristobalite or tridymite is bound to have half of its presenting facets in the form of an acute tenaille composed of the electropositive silicyl ion. The latter is practically isomorphous with carbon monoxide (of definite cholinergic activity) and should have similar potentialities for ferrylheme formation.[18]

CONCLUSIONS

Guanidine reacts with ferrihemoglobin to form a pigment spectroscopically similar to cyanamide ferridehemoglobin. From this fact as well as from the parallel cholinergic activities of cyanamide and guanidine the former is believed to have a carbimid structure.

The stereochemistry of cyanamide and certain other cholinergic substances is analyzed and it is postulated that cholinergic activity may be due to possession of an acute tenaille which may form a polar covalent linkage with the transitional element in the prosthetic nucleus of the cell receptor.

Colloidal silicon dioxide has a structure permitting combination with heme and it may be in this potentiality that the cholinergic effects of silica reside.

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A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF THE HEART. AVES XVI

CHARADRIIFORMES. PART 2[1]

FRED H. GLENNY

Further studies on the arteries in the neck and thorax of the Charadriiformes (9) were made possible by alcoholic specimens loaned to the writer by the United States National Museum and the Chicago Natural History Museum. The writer wishes to express his gratitude to Dr. Alexander Wetmore, Dr. Herbert Friedmann, and Mr. Dwight D. Davis for their help in making these materials available for study.

Twenty specimens, representing thirteen species, were dissected and diagrams of the arrangement of the arteries of the neck and thorax prepared.

MATERIAL[2]

Except where otherwise indicated, single specimens were dissected and diagrams of the arterial arrangement-patterns prepared.

Suborder CHARADRII
- Family *Jacanidae:*
    - *Actophilornis africana* (Gmelin) #291474 USNM
    - *Hydrophasianus chirurgus* (Scopoli) #19912 USNM
    - *Jacana spinosa* (L.) #61352 & #61489 USNM
- Family *Rostratulidae:*
    - *Rostratula benghalensis* (L.) #100500 & #19577 USNM
    - *Nycticryphes semicollaris* (Vieillot) #227167 USNM
    - (*Rostratula semicollaris*) *Nycticryphes semicollaris* (Vieillot) #227601 USNM
- Family *Haematopodidae:*
    - *Haematopus o. ostralegus* (L.) #292354 USNM
- Family *Scolopacidae:*
    - *Totanus* [*Tringa*] *flavipes* (Gmelin) #106050 CNHM
- Family *Reçurvirostridae:*
    - *Recurvirostra americana* (Gmelin) #106062 CNHM
- Family *Glareoloidae:*
    - *Glareola maldivarum* J. R. Forster #19574 & #20223 USNM
- Family *Thinocoridae:*
    - *Thinocorus rumicivorus* Eschscholtz #227599 & #227977 USNM
- Family *Chionididae:*
    - *Chionis minor* Hartlaub #70350 & #70351 USNM

Suborder LARI
- Family *Laridae:*
    - *Larus hyperboreus* (Gunnerus) #97308 CNHM
- Family *Rynchopidae:*
    - *Rynchops n. nigra* L. #320240 & #346680 USNM

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[1] Contributions from Blue Sea Lake Biological Laboratory, Messines, P. Q.

[2] Numbers refer to catalogue numbers of alcoholic specimens:
USNM = United States National Museum.
CNHM = Chicago Natural History Museum.

OBSERVATIONS

The basic ordinal arrangement-pattern for arteries in the neck and thorax of the Charadriiformes appears to be fairly consistent, and is as follows: bicarotidinae normales; ligamentum aortae persistent; ligamentum botalli (right) variable; subclavian series (medial to lateral)—*coracoid major*, with sternotracheal branch normal, *axillary*, *intercostal* (single or bifurcated), and two *pectoral* arteries; syringo-tracheal arteries usually arise as branches of the *ducti shawi* which in turn are usually produced as derivatives of the common carotid arteries *a priori* origin of the superficial cervical and internal carotid (trunk) arteries. Rarely the ductus shawi may arise as a branch of the cervico-vertebral or superficial cervical arteries. The thyroid glands are supplied by short branches from the central or lateral face of the common carotids near the normal origin of the ductus shawi.

Presence of an accessory oesophageal artery (9, Fig. 1) is variable as previously indicated. Retention or persistence of the right ligamentum botalli varies among the species within a family, and the rate of atrophy may likewise be a variable factor (3, 4, & 6). In some of the species, it appears that this vestigeal structure tends to fuse with the ventral face of the right radix aortae and, as a result, tends to lose its individual identity as a separate structure in the adult.

It is likewise true that further progressive atrophy may occur in the case of the vestigeal left ligamentum aortae. This structure, however, tends to become intimately associated with the connective tissue of the pleural cavity. It should be noted that atrophy of the ligamentum aortae may proceed at a rate entirely independent from that of the ligamentum botalli, and that while the right ligamentum botalli may be completely atrophied or fused to the functional radix aortae, the ligamentum aortae may persist as a very prominent vestige. On the other hand, in several forms already studied, there are several instances in which a relatively small or greatly reduced ligamentum botalli was observed along with a very small, much reduced ligamentum aortae.

Jacanidae: In *Actophilornis africanus*, *Hydrophasianus chirurgus*, and *Jacana spinosa* the ductus shawi arises from the common carotid artery, but in *Hydrophasianus* the accessory oesophageal artery appears to arise from the left ductus shawi near its origin from the common carotid, while in both *Actophilornis* and *Jacana* this vessel has an independent origin from the common carotid near the point of origin of the superficial cervicals. Vertebral and lateral superficial cervical arteries usually have a common origin (cervico-vertebral) from the common carotid in both *Actophilornis* and *Hydrophasianus*, while both of these vessels have separate points of origin in *Jacana*.

In each of these three species, the ligamentum aortae is present, but much reduced; the ligamentum botalli fuses with the functional radix aortae and persists only as a very fine white line on the ventral face of the radix. The subscapular arteries arise as branches of the superficial cervical arteries.

In *Actophilornis* there is an extreme dorso-lateral displacement of both the trachea and oesophagus. The lower two-thirds of the trachea is laterally displaced with the oesophagus. In *Hydrophasianus* there is only a slight lateral displacement of the trachea.

Rostratulidae: The ligamentum aortae is large and prominent in both *Rostratula benghalensis* and *Nycticryphes semicollaris;* the ligamentum botalli is usually completely atrophied in the adult of *Rostratula* and remains as a thin, incomplete ligament in *Nycticryphes*. The ductus shawi follows the normal ordinal pattern, while an accessory oesophageal artery from the left side appears to be lacking, or is at least much reduced, in both species.

In *Rostratula* the vertebral and superficial cervical arteries arise separately from the common carotid, while in *Nycticryphes* at least a short cervico-vertebral artery arises from the common carotid. After running a very short course, the cervico-vertebral artery divides to form the vertebral and superficial cervical arteries. The right superficial cervical artery of *Rostratula* appears to bifurcate into lateral and ventral branches which afford a better distribution of blood to the oesophagus.

The trachea is somewhat laterally displaced in both *Rostratula* and *Nycticryphes;* this is accompanied by a somewhat dorso-lateral displacement of the oesophagus.

Details in the arrangement-pattern of USNM specimens #227601 and #227167 are identical and should be assigned to *Nycticryphes semicollaris.*

Haematopodidae: Arteries of the lower cervical region of *Haematopus o. ostralegus* are well-developed and serve to afford considerable blood supply to the tissues of the neck, including the oesophagus. Origin of the ductus shawi is normal; the accessory oesophageal artery arises as a branch of the left ductus shawi near the point of origin of the latter from the common carotid artery. The cervico-vertebral artery sends off the ventral superficial cervical and vertebral arteries before forming the scapulo-cervical which gives rise to the subscapular artery and then passes anteriorly as the lateral superficial cervical artery. The right ventral superficial cervical serves as the primary ascending oesophageal artery. The lateral superficial cervicals are comparable to the *comes nervi vagi* of Beddard and others.

The ligamentum aortae is a large prominent vestige which may retain its connection with the pulmonary artery as does the smaller ligamentum botalli of the right side.

The carina is deep, and on it are produced well-developed pectoral muscles.

Scolopacidae: The arrangement of arteries in *Totanus flavipes* is quite similar to that in *Oxyechus v. vociferus* (9, Fig. 1), but there are certain minor differences in details.

The vertebral and superficial cervical arteries usually arise separately, but in the same region, from the common carotid, and do not appear to unite to form a cervico-vertebral artery. In individual cases, however, this might occur due largely to the close association of these two vessels. The accessory oesophageal artery arises as a branch of the left superficial cervical artery, and the subscapular arteries arise as branches of the cervicals.

In *Totanus flavipes*, the ligamentum aortae is a much reduced and very thin ligamentous vestige, while the ligamentum botalli is entirely obliterated in the adult.

Both the oesophagus and the trachea are dextro-laterally displaced in *Totanus* along the major length of the neck.

Recurvirostridae: Recurvirostra americana is interesting for its several minor differences in arrangement-pattern. The ductus shawi and syringo-tracheal arteries arise not directly from the common carotid but from the cervico-vertebral arteries which give rise to the vertebral, subscapular, and superficial cervical arteries at a common point of origin. The superficial cervical arteries further divide into ventral and lateral vessels. The main oesophageal and tracheal blood supply is afforded by the cervical arteries of the right side. The intercostal arteries bifurcate into lateral and dorso-lateral branches. The ligamentum aortae remains as a significantly prominent vestige, while the basal or distal portion of the ligamentum botalli is readily visable, tapering to a very thin white ligament at its proximal end.

There is a dextro-lateral displacement of the oesophagus and trachea in *Recurvirostra.*

Glareolidae: Glareola maldivarum is similar to *Nycticryphes semicollaris* in arrangement, except that an accessory oesophageal artery is present, and this vessel arises as a branch of the left common carotid artery. The cervical and vertebral arteries form a common vessel to join the common carotid. A small ventro-lateral cervical artery may be present, in addition to the normal superficial cervical artery, on the right side. The ligamentum aortae is reasonably large and prominent, while the ligamentum botalli is so greatly reduced as to be almost completely obliterated.

Thinocoridae: Thinocorus rumicivorus is simple in arrangement, but shows some variation in point of origin of the vertebral and cervical arteries. Generally, however, it would appear that the vertebral and cervical arteries tend to arise separately from the common carotids, although they may occasionally join to form a common vessel. The accessory oesophageal artery arises as a branch of the left superficial cervical artery.

In the above respects, *Thinocorus* closely resembles *Totanus flavipes*. The thyroid arteries arise as short branches of the left and right superficial cervical arteries. The ligamentum aortae is prominent, but the ligamentum botalli is entirely lacking.

Chionidae: Both the ligamentum aortae and ligamentum botalli are present and prominent in *Chionis minor*. The intercostals arise more laterally in *Chionis* and appear to branch from the base of the posterior pectoral artery.

The right common carotid gives rise to the ascending oesophageal artery which sends off the thyroid arteries, the lateral superficial cervical artery which gives off the subscapular artery, the vertebral artery, and finally the internal carotid (trunk) artery. The left common carotid produces a cervico-oesophageal artery which then divides to form the left superficial cervical artery from which the left subscapular arises as a branch as does the accessory oesophageal artery which sends off small branches to the thyroid gland, a vertebral artery, and finally the left internal carotid (trunk) artery. The left vertebral artery was observed to send off cervical segmental arteries.

Laridae: Larus hyperboreus is similar in basic arrangement to *L. argentatus* (9, Fig. 2). Minor differences appear, however, in the origin of the verterbal arteries (these may join with the superficial cervicals to form a common vessel or they may arise separately from the common carotids), and in the presence of an accessory oesophageal artery which arises as a branch of the left accessory superficial cervical artery. Both accessory cervical arteries send off small branches to the ventral collis before giving rise to several small vessels along their course along the ventro-lateral cervical region. The right accessory cervical vessel appears to function as an ascending oesophageal artery.

Both the ligamentum aortae and ligamentum botalli are quite prominent vestiges and appear to maintain their embryonic attachments.

Rynchopidae: Rynchops n. nigra is similar in arrangement to *Hydrophasianus chirurgus* except that the accessory oesophageal artery arises separately from the common carotid near the point of origin of the cervico-vertebral artery. The right superficial cervical artery serves as the primary ascending oesophageal artery.

The ligamentum aortae is prominent distally but becomes quite thin proximally. The ligamentum botalli is very much reduced along its entire length.

Both the oesophagus and trachea of *Rynchops* are dextrolaterally displaced with the result that the trachea does not lie along the ventral medial cervical line as is the case with most orders of birds.

DISCUSSION

It may be seen from the above observations that within both the families and species, herein represented, there are minor differences in the arrangement-pattern of cervical arteries, along with differences in the degree of atrophy of both the ligamentum aortae and ligamentum botalli. Such differences may be accounted for on the basis of specific phylogenetic divergences. The group included in this study exhibited a relatively narrow range of variation, however, and it will be noted that the essential differences result from various combinations in origin of the vertebral, cervical, and accessory oesophageal arteries.

It is of especial interest to note that the basic ordinal arrangement-pattern is constant, and that it shows close similarity to the basic arrangement-patterns of Anseriformes (5), Ciconiiformes (7), and Gaviiformes (8). Greater variation in the origin of the thoracic vessels, along with wider range in arterial arrangement in the cervical region, is found in several other orders of *aves bicarotidinae normales*.

Observations *a propos* variability in degree of retention of the ligamentum aortae and ligamentum botalli might lead one to believe that certain unknown factors of growth and development are involved in the various rates of atrophy as well as levels of atrophic degeneration. Since atrophy of several of these embryonic vestiges appears to operate on gradient levels—from left to right—factors involved in control of rates of atrophy might be referred to as *Atrophic Gradient Factors*. These factors appear to operate in conjunction with, but somewhat independent of, each other under normal conditions, and may account for some differences in retention of certain embryonic vestiges among several species within a family or order of birds.

It is not inconceivable that each structure which has definite embryonic functions and which subsequently becomes morphologically and functionally altered may have growth or developmental factors controlling rates and extent of structural and functional modification along with factors responsible for initiation of a chain of events ultimately resulting in the adult condition. It is evident that these initiating and gradient factors do not always function properly. Results of such malfunctioning have been observed in several instances (1, 2, 3).

SUMMARY

Thirteen species of Charadriiformes, representing ten families, were dissected, and diagrams of the arterial arrangement-patterns prepared. An uncomplicated basic ordinal arrangement of thoracic and cervical arteries was observed. Some minor individual or family differences were observed and noted. The range of differences was limited, and tended to lie within the range of normal ordinal phyletic deviation. It would appear that the Charadriiformes show a fairly stable ordinal arterial arrangement, not always observed in various orders of birds.

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ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE

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Publications

Secretary, Chairman

A. C. Anderson	Term expires 1949
R. A. Hefner	Term expires 1951

Conservation

Arthur Harper, Chairman	Term expires 1949
George W. White	Term expires 1949
C. E. Taft	Term expires 1949
R. V. Bangham	Term expires 1950
R. W. Franks	Term expires 1950
C. A. Dambach	Term expires 1950
E. S. Thomas	Term expires 1951
P. B. Sears	Term expires 1951
Frank J. Wright	Term expires 1951

Necrology

H. R. Eggleston	Term expires 1949
J. E. Carman, Chairman	Term expires 1950
Carl Ver Steeg	Term expires 1951

Resolutions

W. C. Kraatz, Chairman	Term expires 1949
P. B. Sears	Term expires 1950
W. C. Beaver	Term expires 1951

Trustees of Research Fund

Herbert O. Osborn, Chairman	Term expires 1949
E. Lucy Braun	Term expires 1950
E. N. Transeau	Term expires 1951

Academy Representatives

1. On the Joint Administrative Board of The Ohio Journal of Science:

A. C. Anderson	Term expires 1949
R. A. Hefner	Term expires 1951

2. On the Council of the A. A. A. S.: Secretary.
3. On the Save-Outdoor-Ohio Council: R. W. Franks.

The Council for 1948–1949

Anderson, A. C.
Barbour, G. B.
Bernhagen, R. J.
Bills, A. G.
Blaydes, G. W.
Bodenberg, E. T.
Bossert, R. G.
Bowman, H. H. M.
Eisen, Edna E.
Elliott, Rush
Everhart, W. A.
Hahnert, W. F.
Hale, W. Kelley
Harper, A. R.
Hefner, R. A.
Hulme, H. C.
Hydell, P. W.
Lindsey, A. W.
Manchester, R. E.
Michaelis, Lillian
Miller, John A.
Osborn, Herbert O.
Pool, M. P.
Puppel, I. D.
Pyle, W. R.
Spuhler, J. N.
Stanfield, J. F.
Stehr, W. C.
Sturgeon, M. T.
Tidd, W. M.
Utley, F. L.
Wilson, C. M.

REPORT OF THE FIFTY-SEVENTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The Academy was privileged to participate in the year-long activities in the celebration of the seventy-fifth anniversary of The University of Toledo by holding the annual meeting on the campus on May 6, 7, and 8. Excellent arrangements had been made by the Local Committee, with Dr. A. N. Solberg as chairman, attendance was good and programs were presented by all sections of the Academy.

The meeting opened with the Executive Committee and Council meetings on May 6, and sectional meetings were held on May 7 and 8. The annual banquet was held at the Secor Hotel on Friday evening at 6:30. Dr. A. N. Solberg served as an able toastmaster. A brief and interesting history of the University of Toledo was presented by Dr. Frank Hickerson. Greetings were extended by President W. W. White of the University of Toledo, and response was given for the Academy by Dr. F. S. Howlett. The presidential address was given by Dr. A. W. Lindsey on the subject, "The Fallacy of Communism."

Dr. F. H. Krecker presented a report on the organization and activities of the new reactivated section formerly known as the Junior Academy and now known as the Science Education section.

The annual report of the secretary was presented and carried an analysis of the membership of the Academy at present and the announcement of the election of the following members as fellows:

Clarence F. Clark
Floyd B. Chapman
John W. Coulter
Charles M. Diserens
Frank M. Fletcher, Jr.
Earl L. Green
Fred H. Householder
Wendell R. Koch
Harry V. Knorr
Howard K. Justice
Arthur L. Lutz
O. E. McClure
Harold E. Newhard
T. D. Phillips
W. R. Pyle
Hallock F. Raupp
H. H. Roseberry
James M. Spuhler
J. Fisher Stanfield
Will S. Thompson
Clarence W. Wallace

The report of the Nominating Committee was presented by Dr. W. C. Beaver, of the Necrology Committee by Dr. J. E. Carman, and of the Resolutions Committee by Dr. W. C. Kraatz.

Respectfully submitted,

Rush Elliott, *Secretary.*

REPORT OF THE EXECUTIVE COMMITTEE AND COUNCIL

The Executive Committee met on January 16, and again on May 6, and the Council on January 17, and again on May 6.

A petition was received from a group of new members of the Academy for the recognition of a section of the Academy to be known as the Science Education section, to be Section J, and to replace the former Junior Academy Section. This will be made up chiefly of high school science teachers. Petition was approved.

A special committee was appointed (R. L. Edwards, chairman, F. H. Krecker, G. W. Blaydes, W. M. Tidd and James Vaughn) to make a study of the allocation of funds collected as annual membership dues and to report at the next winter meeting of the Council.

The Membership Committee reported 140 new members. This brings the total membership to more than 850, the largest in the history of the Academy. The applicants were duly accepted. Nominations for Fellowship were presented and approved (see report of Annual Meeting).

The appointment of Miss Lillian Michaelis of The Ohio State University as Librarian of the Academy was approved.

A proposal by the secretary for a regular plan for the location of the annual meeting on a geographical basis was adopted. This is in effect that every other year the meeting should be held at an institution in the central part of the state and on alternate years in the four quarters in a rotary plan.

Invitations for the 1949 meeting were received from Miami University and Denison University and for the 1950 meeting from Capital University as a part of the Centennial program. The invitations from Miami, from which an invitation for the 1948 meeting had also been received, and from Capital were accepted and the invitation from Denison will again be extended for a later date. The 1949 meeting will have to be set for an earlier date than the early part of May, to which we have been accustomed in the past several years.

Respectfully submitted,

Rush Elliott, *Secretary.*

REPORT OF THE TREASURER

COLUMBUS, OHIO, August 10, 1948.

To the Ohio Academy of Science:

I submit herewith a financial statement of the condition of the Ohio Academy of Science as of December 31, 1947. The books have been audited and the opinion of the auditor is herewith attached.

Respectfully submitted,

WILBUR M. TIDD, *Treasurer.*

OHIO ACADEMY OF SCIENCE BALANCE SHEET

As at December 31, 1947

ASSETS

CURRENT EXPENSE FUND:		
Cash in Bank		$ 540.13
Bonds owned:		
U. S. War Savings Bonds Series F (cost)	$ 111 00	
U. S. War Savings Bonds Series G (cost)	1,900.00	
Total Bonds Owned		2,011 00
Total Assets—Current Expense Fund		$2,551 13
RESEARCH FUND:		
Cash in Bank	$ 247.31	
Banc-Ohio Securities Stock	437.50	
Bonds owned:		
Fort Hayes Hotel, Columbus, Ohio (cost)	1,300.00	
U. S. War Savings Bonds, Series G (cost)	300 00	
Total Assets—Research Fund		2,284.81
Total Assets		$4,835 94

LIABILITIES AND NET WORTH

CURRENT EXPENSE FUND:		
Liabilities—		
Accounts payable		$ 15.00
Deferred Credits—		
1948 Dues collected in 1947		57.50
Total Liabilities and Deferred Credits		$ 72.50
NET WORTH:		
Ohio Academy of Science—		
Current Expense Fund	$2,478.63	
Research Fund	2,284.81	
Total Net Worth		4,763 44
Total Liabilities and Net Worth		$4,835.94

OHIO ACADEMY OF SCIENCE STATEMENT OF INCOME AND EXPENSE

For the Year Ended December 31, 1947

INCOME:	
Dues from Members	$1,775.00
Grants for Research	307.00
Sale of Publications	61.26
Interest on Bonds	41.25
Total Income	$2,184 51

Operating Expenses:		
Subscriptions—Ohio Journal of Science	$1,026 00	
Printing Proceedings, 1947	240.70	
Printing—Other	304 45	
Research Grants	307.00	
Postage and Office Expense	172 13	
Secretary's Honorarium	100 00	
Binding Reports	13 14	
Miscellaneous	3 10	
Total Operating Expense	$2,166 52	
Non-Operating Expense:		
Ohio Journal of Science—special grant	99 00	
Total Expenses		2,265.52
Excess of Expense Over Income		$ 81 01

AUDITOR'S CERTIFICATE

Columbus, Ohio, July 1, 1948.

To the Ohio Academy of Science, Columbus, Ohio.

Gentlemen:

In accordance with your instructions, I have examined the accounts and records of the Ohio Academy of Science for the year ended December 31, 1947.

A detailed audit was made of all transactions handled by the treasurer. Cash in bank was verified by bank certification. Securities in safety deposit box were verified by personal examination. My examination was made in accordance with generally accepted auditing standards.

In my opinion the accompanying balance sheet and the statement of income and expense (cash basis) fairly presents the financial position at December 31, 1947, and the results of operations on a cash basis for the year ending December 31, 1947. These statements are in conformity with generally accepted accounting principles.

Respectfully yours,

D. M. Shonting,
Certified Public Accountant.

REPORT OF THE TRUSTEES OF THE RESEARCH FUND

Your trustees beg to report for the year 1947–48 that the grant to Doctor E. Lucy Braun has been completed. Her grant, as stated in a previous report, was prior to her appointment as a member of the Board. Also, a grant for $31.50 was made to R. D. Wood for an article with illustrations on the Caraceae of Put-in-Bay, published in the *Ohio Journal of Science.*

We have also made a grant to Doctor Margaret Fulford of the University of Cincinnati in the amount of $153.00, which amount has been received from the A. A. A. S. and is to assist her in her studies of Hepaticae.

The statement by Doctor Tidd as Treasurer will contain details of the assets and funds available for grants from the Research Fund of the Academy.

There is a probable annual grant to come from the A. A. A. S. for the present year which will be about $150.00. There will also be some available funds as a balance in the Academy Research Fund and it is desirable that applications for assistance be made promptly. This is especially true for the grant from the A. A. A. S. which is available during the year. Applications for assistance should be made to the Research Fund, Ohio Academy of Science, Herbert Osborn, Chairman, B. & Z. Building, Ohio State University, Columbus 10, Ohio.

Respectfully submitted,

E. Lucy Braun,
J. Ernest Carman,
Herbert Osborn, *Chairman.*

REPORT OF THE LIBRARY COMMITTEE

The library has indeed felt the absence of Mrs. Miller's capable hand, but has carried on after a fashion which we hope will show constant improvement.

Back issues of the Ohio Journal of Science to cover the war years, have been sent through the Smithsonian Institution to seven foreign countries. Four new exchanges have been added. Lacks have been filled on request.

The report of the sales of publications handled by the library is incorporated in the report of the Academy Treasurer.

Respectfully submitted,

LILLIAN MICHAELIS.

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the Joint Administrative Board of the Ohio Journal of Science was held at Columbus, Ohio, April 10, 1948. Dr. Blaydes, having called the meeting of the board, presided at its organization. Present were Drs. Spieker and Meyer, representing the Ohio State University; Drs. Hefner and Anderson, representing the Ohio Academy of Science, and Drs. Blaydes and Miller, representing the Ohio Journal of Science. Upon a motion by Dr. Meyer and seconded by Dr. Hefner, Dr. Spieker was elected to serve as Chairman of the Board. Dr. Miller continued to serve as secretary.

The minutes of the preceding meeting were read and approved.

The chair called for a report of the Business Manager. Dr. Miller's report was in the form of a financial statement for Volume 47 of the Journal, a copy of which is herewith attached. Dr. Anderson moved the acceptance of the financial report, the motion was seconded by Dr. Hefner and passed by the board.

Dr. Miller, in commenting upon the financial position of the Journal, called the attention of the board to the gain in assets of $281.87 for Volume 47, over Volume 46. He explained that this was due to a combination of favorable factors, the failure of any one would have caused a deficit in the current operating expense. The Ohio Academy, for example, paid into the Journal for pro-rata dues $273.00 more during 1947 than in 1946. The number of pages of the Journal was reduced and a number of special papers and author's payment of publication costs were obtained, thus further effecting an economy of publication.

The increase in Academy memberships and the restoration of foreign exchanges and subscriptions has necessitated an increase in the number of copies of the Journal to be printed in the future. This will add to the present cost of publication.

Upon the suggestions of the Business Manager, Dr. Hefner moved and Dr. Meyer seconded a motion to authorize the Business Manager to devise, in cooperation with Dr. Tidd, of the Academy, a symbol to be placed on the stencil of all those receiving the Journal. Motion carried.

The chairman then called for the report of the Editor. Dr. Blaydes then presented a review of papers presented in Volume 47. He called attention to the variety of papers in this volume, 10 science divisions being represented through 41 papers, totaling 265 pages. Eight book reviews were also published. The editor called the attention of the board to the limited number of papers on hand and wished to make known to this body that early publication in the Journal is possible. Dr. Hefner moved the acceptance of the Editor's report, seconded by Dr. Anderson. Passed by the Board.

The Chairman then called for an election of Business Manager, and Editor for Volume 48.

Dr. Hefner moved the appointment of Dr. Miller as Business Manager, seconded by Dr. Meyer. Passed by the Board.

Dr. Meyer moved the appointment of Dr. Blaydes as Editor, seconded by Dr. Hefner. Passed by the Board.

Dr. Hefner moved that the Auditing Committee be composed of Dr. Meyer and Dr. Spieker, seconded by Dr. Anderson. Passed by the Board.

Under new business, it was the expression of the Board that means should be used to stimulate papers from all sections of the Academy. The Secretary was directed to include in the report to the Academy an appeal to the Vice-Presidents of each section to encourage their section affiliates to offer papers in the Journal. The Journal can print only those papers that are submitted, and if section members are disappointed in the offerings in the Journal from their field, it is because they do not offer for publication in the Journal their own researches.

As informal discussion regarding the forthcoming consideration on the part of a committee to study Academy membership without the Journal followed. It was agreed that the Journal cooperate with the Junior Academy and other interested groups in making available space in the Journal for articles of interest to such groups.

There being no further business to come before the Board at this time, it was adjourned.

Respectfully submitted,

JOHN A. MILLER,
Secretary of the Board.

THE OHIO JOURNAL OF SCIENCE

Fiscal Year 1947

RECEIPTS

Balance from 1946	$ 251.65
University allowance	1,000.00
Ohio Academy of Science—pro rata of dues	1,033.50
Ohio Academy of Science—proceedings	240 70
Ohio Academy of Science—delinquent payment	68 75
Subscriptions	140 00
Sale of back numbers	52 09
Author's payment for plates	167.70
Payments by authors and institutions of publication costs	617.66
	$3,572 05

EXPENDITURES

Spahr and Glenn, Printing—Vol. 47 and envelopes and stationery	$2,565 14
Bucher Engraving Company	367 85
Postmaster	85.11
Bank Charges	1.43
Clerical assistance	19.00
	$3,038 53
Balance on hand, February 20, 1948 (Huntington National Bank)	533 52
	$3,572 05

REPORT OF THE COMMITTEE ON CONSERVATION

The report of your Conservation committee, which is herewith respectfully submitted, is based upon the universally recognized concept that all activities designed to conserve our natural resources should be founded on and guided by a scientific understanding of those natural resources. Our recommendations also have considered the fact that, since all the affairs of mankind are greatly dependent upon the richness, abundance and availability of natural resources, it becomes the civic duty of every citizen to take an active part in the program of conservation, contributing specially those skills and understandings which form a part of his personal vocation. Upon both these counts, the members of the Ohio Academy of Science have a special opportunity and upon them devolves a special duty to take an active part in the public program of conservation.

In the field of research, whether involving the physical, biological or social sciences, the members of the Ohio Academy of Science possess sound and proven data that would be valuable guidance to conservation technicians, and also to legislators and administrators of those agencies which plan and execute conservation programs. All this is equally true of those members engaged in field work, such as ecological surveys. Your committee recommends that the Academy as a whole and as individual members shall here resolve that such scientific data shall not only be made readily available but that it shall become a part of the public conservation program through vigorous personal participation in that program.

The success of any public program is very largely determined by public opinion, which profoundly affects both legislation and public behavior—the future of conservation is largely a matter of public opinion. The members of the Ohio Academy of Science occupy a position that provides an outstanding opportunity to promote proper understandings concerning conservation through education. Many members have daily contact with large numbers of our future citizens in the classroom and have countless opportunities to use scientific facts to drive home the social importance of conservation of our natural resources. Your committee recognizes that the prime purpose of teaching is not to fill heads with knowledge—it is to guide hands and feet into a pattern of behavior that will enable students to live better with each other and with their world in every day life.

The teacher should remember that his position causes his opinions to be greatly respected in the community in which he lives. It is his duty as well as his privilege to mould the opinion and guide the behavior of his community. In meetings of civic groups and in the columns of local newspapers, the Academy member can do much to influence community thought and action in matters of conservation. Your committee recommends that members of the Academy seek and accept opportunities to render this kind of community service.

Another field of conservation education lies in the boys and girls of our public schools. In this connection, attention is called to the new section of the Academy for public school teachers. As a part of their activities, this new section will develop and guide the Junior Academy of Science, whose membership will be composed of boys and girls of the public schools. The value of this section and of the Junior Academy of Science to all that the Ohio Academy of

Science stands for and its value to conservation is apparent. Your committee strongly recommends that the Academy shall give the new section a cordial welcome and that individual members shall give it active assistance.

Respectfully submitted,

Clarence Taft,	C. L. Dow,
E. W. E. Schear,	R. W. Franks,
R. V. Bangham,	Guy Conrey,
	A. R. Harper, *Chairman*.

REPORT OF THE COMMITTEE ON NECROLOGY

The Committee on Necrology reports with deep regret the death of six members of the Academy since the last annual meeting. The following memorial statements were written by colleagues of the deceased members as indicated by the name following each statement.

Respectfully submitted,

E. G. Detweiler,
H. R. Eggleston,
J. Ernest Carman, *Chairman*.

Guy Woolard Conrey

Guy Woolard Conrey, Professor of Agronomy, Ohio State University, died at his home April 20, 1948. He was born in Northboro, Iowa, December 10, 1887. Surviving are his wife and two daughters.

Dr. Conrey received the B.A. and M.A. degrees from the University of Michigan in 1908 and 1909, respectively, and the Ph.D. degree at the Ohio State University in 1921. Dr. Conrey served as Assistant in the Division of Soils of the Wisconsin Geological and Natural History Survey from 1909 to 1917. He came to Ohio in 1917 as Instructor in soils, and Assistant in Soil Survey, was placed in charge of the Soil Survey in Ohio in 1925, and was progressively promoted to Professor of Agronomy at Ohio State University and Associate Agronomist of the Ohio Agricultural Experiment Station.

Dr. Conrey was a fellow of the Ohio Academy of Science and the American Society of Agronomy. He was a member of the Soil Science Society of America, the American Association for the Advancement of Science, the American Geographic Association, the American Forestry Society, the Geophysical Union, and the International Society of Soil Science. His interest and activity in his profession is evidenced through his several chairmanships and committee assignments that he held in these societies. He was also a member of Sigma Xi, Phi Lambda Upsilon and Gamma Sigma Delta honorary societies.

Dr. Conrey's principal interest was in the field of soil science; specifically, soil morphology classification, technology and land use. He was also intensely interested in geology, mineralogy, and geography, subjects that are closely linked with soil science and his studies have tended to clarify many of the interrelationships of these fields. With a broad concept of the factors involved, Dr. Conrey and his associates have contributed very materially to our present concepts of soil development and classification. Further, his work in the relationships of soil characteristics, soil productivity, and soil management has led to greater practical application of soil research results.

Dr. Conrey was an inspiring teacher, both in the classroom and in the field. His thorough understanding of the field of soils, and its relationship to other sciences, together with his kindly nature and ability to explain complex relationships in simple language, insured his popularity as a lecturer. His courses were among the most popular in the college. His activity in the fields of geology, geography, and economics gave him a rare insight into the field of soils that was reflected in his teaching as well as his research activities.

Although his health was impaired, Dr. Conrey assumed extra duties directly concerned with the war effort in 1941. In addition to his already heavy load of work, he taught courses in A.S.T.P. and applied his soils knowledge in locating airfield, manufacturing and war materials storage sites. Even after a severe stroke in 1944, from which he never fully recovered, he contributed a great deal through conferences, correspondence, and his writings.

—*D. D. Mason and D. R. Dood.*

John Scott Gillespie

Mr. J. S. Gillespie, a member of the Academy for 22 years, died at his home in Columbus on August 31, 1947. Mrs. Gillespie had preceded him by about ten years.

Mr. Gillespie was a geologist who had been on the staff of the Ohio Fuel Gas Company from 1918 until retired from active service in 1936. He was born on February 22, 1864, on a farm near Washington C. H., Ohio. After finishing school he took employment with the D. T. & I.

Railway at Waverly, where he learned telegraphy and had his first experience in railroad operation. This career he followed for a number of years, holding the position of division superintendent of the B. & O. at Newark and at Zanesville. Later he held important posts with several western roads, his work finally taking him to Spokane, Washington, where he was so impressed with the future of the Northwest that he went into promotional work and served as secretary of the Spokane Chamber of Commerce for a time.

From early youth Mr. Gillespie was greatly interested in geology. His work and travel so intensified that interest that his avocation finally became his full-time occupation. His geological training was almost entirely through reading, experience, and observation, but it was sound training, as those who knew him will testify.

John Scott Gillespie was one of those rare individuals who seemed younger than his years because of his abounding curiosity, and particularly because of his great interest in scientific investigation. His many friends remember him as a gentle man of penetrating insight, of kindly wit, and of unwavering loyalty.—*K. C. Cottingham.*

JOHN SAMUEL HOUSER

John Samuel Houser was born April 10, 1881, on a farm near Oxford, Kansas. He graduated from high school in Oxford and then entered Kansas State Agricultural College where he became interested in the subject of entomology. He was graduated with the class of 1904 and immediately went to work in the Department of Entomology at the Ohio Agricultural Experiment Station. In 1907 he was granted a two-year leave from the Ohio Station to carry on entomological work in Cuba—working at the Estacion Experimental Agronomica at Santiago de Las Vegas. He returned to the Ohio Experiment Station as an associate in 1909. In 1926, Mr. Houser became chief of the Department of Entomology, which position he occupied at the time of his death. He received the M.S. degree from Cornell University in 1911, and the honorary degree of Doctor of Science from his alma mater, Kansas State Agricultural College, in 1944.

Dr. Houser's chief interest was in the field of forest insects. He loved to camp in the State Forests, to roam the hills studying trees and insects. He was the first entomologist to use the airplane to disperse insecticides—the test being directed against the catalpa hornworm which was devastating a grove in Miami County, Ohio, in the summer of 1921. He was a charter member of the Entomological Society of America, a member of the American Association for the Advancement of Science, Past President of the American Association of Economic Entomologists, and a Fellow of the Ohio Academy of Science.

Dr. Houser was the author of many scientific and popular entomological papers. His best known publication is the Ohio Experiment Station Bulletin entitled: "Shade and Forest Tree Insects" which, though published nearly thirty years ago is still used by working entomologists.

Dr. Houser died suddenly on the night of June 25, 1947, from the effect of a recurring heart attack from which he had been suffering for about two years. His wife, Elizabeth, died in 1941. He is survived by two married daughters; by a brother and a sister, each living in Kansas.—*T. H. Parks.*

RAYMOND JESSE SEYMOUR

The death of Professor Emeritus Raymond Jesse Seymour which occurred on April 10, 1948, brought to a close the career of a man who had spent 45 years in faithful and distinguished service to the College of Medicine and the Ohio State University.

Dr. Seymour was born in Groveport, Ohio, in 1878. He received the Bachelor of Science Degree from the Ohio State University in 1900, the Degree Master of Science from Tufts College in 1901, and the Degree Doctor of Medicine from the Ohio Medical University in 1903. He began his career as a teacher in 1903 when he was appointed an assistant in the Department of Pathology. He joined the staff of the Physiology Department in 1905, and served this department continuously until his death. He was given the rank of Professor of Physiology in 1928 and served for seven years as Chairman of the Department. Dr. Seymour was particularly gifted as a teacher of beginning students and was unexcelled in the clear, concise, and simple exposition of the fundamental concepts of physiology. Thousands of students have profited from their associations with him. His broad background of preparation and his fine personality made him a leader among his colleagues and a wise councillor and guide of students. In 1944, poor health forced him to give up active teaching and he was given the rank of Emeritus Professor. However, even after his retirement, he maintained his active interest in the Department, and was always ready to offer his advice and council in matters of administration.

For many years Dr. Seymour was an active and enthusiastic member of the Ohio Academy of Science. From 1920 to 1922 he served as Vice-President of the Academy and Chairman of the Medical Science Section. His council and advice will be sorely missed, and the Ohio Academy of Science wishes to record their sincere appreciation of Dr. Seymour's long and distinguished services and to express their profound sorrow at his passing.—*F. A. Hitchcock.*

JULIUS F. STONE

Julius F. Stone was a successful banker and industrialist but he was quite at home wherever the language of science was spoken. He was a distinguished explorer in his own right and an amateur astronomer of note. He was so impressed by the importance of biology that he gave Gibralter Island, long the summer home of Jay Cooke, the Civil War banker, to the Ohio State University as the site for its year-round marine biological laboratory. He was a prime mover in the University's Research Foundation which he served as president. He was the modest and often anonymous donor of scientific apparatus and equipment to the University—notably its cyclotron. During his long years of service on the University Board of Trustees he was always mindful of the scientific and technical departments. As evidence of his own standing as a man of science, he was a fellow of the American Geographical Society and of the Royal Astronomical Society. He also held membership in the American Astronomical Society, in the American Society of Mechanical Engineers, and in the exclusive Explorers' Club, of New York. He made the first organized boat trip with a party through the entire course of the Colorado River. The story of this trip was told in his Canyon Country, published in 1932. He was a master of the English language—spoken or written,— a rare companion, a man whose interests were as broad as all human experience. The cause of science, and particularly of scientific research, lost a devoted follower when he died in 1947.—*James E. Pollard.*

LEWIS GARDNER WESTGATE

By the death of Dr. Lewis G. Westgate, March 30, 1948, at Delaware, Ohio lost a discerning student of local geology, the nation one of its most adept teachers, and the college world one of its most skillful educators. Dr. Westgate in many respects was a unique personality, although outwardly scarcely different from other scholars. Much interested in the interpretation of geology in the field, he was first and foremost interested in developing the scholarly and scientific potentialities of college students. He was intolerant of sham and subterfuge, either by students or men in private or public activities. The student who tried to "get by" in his classes soon learned, often to his discomfiture, what education really meant.

He was widely read, scholarly, and an independent and precise thinker. His formula for teaching might be stated in two words: What? Why? His type of humor, at times rather puchish, and inciseveness of speech, coupled with pertinent illustrations from the current scene, made his chapel talks long remembered.

Dr. Westgate was born in 1868 in Phenix, R. I. His B.A. degree was obtained at "Old" Wesleyan in 1890; his M.A. from Harvard in 1892, and his Ph.D. there in 1896. At Wesleyan he was under the influence of renowned men, including William North Rice. At Harvard he became more or less a disciple of William Morris Davis, famed geographer and geomorphologist. His first teaching was in the public schools at Evanston, Ill. After several years there he came to Ohio Wesleyan University in 1900 as Professor of Geology. Here he served for the remainder of his life.

He was a Fellow of the Geological Society of America and a member of other scientific societies. He was president of the Ohio Academy of Science in 1910.

His main contribution to the geology of Ohio was the "Geology of Delaware County," published in 1926 as Bulletin 30 of the Geological Survey of Ohio. Numerous papers on various phases of geology were published in technical periodicals and as reports of the U. S. Geological Survey. Articles expressing some of his views on education and the philosophy of living appeared from time to time elsewhere. Several summers were spent in field work for the United States Geological Survey in Alaska and in the western states.—*Arthur Bevan.*

REPORT OF COMMITTEE ON RESOLUTIONS

Be it Resolved, that the members of the Ohio Academy of Science express to the administration of the University of Toledo, and to the Local Committee under the able leadership of Dr. A. N. Solberg, its appreciation of the hospitality so freely extended and the excellent facilities furnished, which have made this, our fifty-seventh annual meeting, so pleasant and successful.

Be it further Resolved, that the Ohio Academy of Science express to President Wilbur W. White and the faculty of the University of Toledo, its felicitations on the achievement of the seventy-fifth anniversary of this notable institution of learning.

Respectfully submitted,

W. C. KRAATZ,
P. B. SEARS,
N. MOGENDORFF, *Chairman.*

THE OHIO JOURNAL OF SCIENCE

VOL. XLVIII NOVEMBER, 1948 No. 6

THE RELATIVE IMPORTANCE OF HUNTING RESTRICTIONS AND LAND USE IN MAINTAINING WILDLIFE POPULATIONS IN OHIO

CHARLES A. DAMBACH,[1]
Department of Zoology and Entomology,
The Ohio State University,
Columbus, Ohio

One of the traditional methods of managing our wildlife resources has been to restrict their use by adoption of regulations designed for that purpose. The taking of game, in some places at least, has been regulated since Biblical times (Deuteronomy 22:6). In our own country the game harvest was at first regulated by certain tribal customs which were in effect before the coming of white settlers. As settlement of the country progressed and wildlife appeared to decline in abundance the simple tribal taboos on the taking of wildlife during the reproductive season gave way to more complex restrictions. These we now speak of as the game laws which govern hunting by some 6,000,000 to 10,000,000 persons in the United States each year.

Presumably the complexity and severity of the regulations adopted provide a rough measurement of wildlife abundance in relation to hunting pressure. If this is true it follows that a study of the game laws should provide an index to past and present wildlife abundance and a measure of the effectiveness of regulations in perpetuating the crop. It is the purpose of this paper to set forth the results of such a study in Ohio.

Interest in the study stemmed from several sources as did material upon which it is based. A chapter by Dr. Paul B. Sears (11) in "The History of Ohio" first aroused the writer's interest in the subject. This interest was further heightened by a challenge from Dr. T. H. Langlois (6) to game administrators to demonstrate that the expenditure of large sums of money for law enforcement by the states was productive of results in terms of higher fish and game populations.

Two excellent sources of useful historical data in this field were available for reference. These include a History of Conservation Restrictions in Ohio, by the late Judge C. M. Finfrock (3) and a Summary of Ohio Game Regulations from 1890 to 1930 which was prepared by Mr. E. L. Wickliff, (12). Neither summary has been prepared for publication. Judge Finfrock, authorized the writer to freely use his data (4) and loaned a typewritten copy of the material for this purpose. Mr. Wickliff kindly permitted the writer to use his material for reference.

The principal sources of data presented in this paper in addition to the above references are the Laws of the Northwest Territory which governed the use of wildlife in Ohio prior to its statehood, the Laws of Ohio passed by the State Legislature, the Orders of the Ohio Conservation Council and later the orders of the Ohio Conservation Commission. The Annual Summary of Fish and Game Laws published by the United State Fish and Wildlife Service was also consulted.

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[1] The writer wishes to express appreciation for assistance in the preparation of this paper to Mr. E. L. Wickliff, who helped materially in furnishing records of Ohio game laws and in suggesting sources of information used in compilation of this report. He wishes also to acknowledge the assistance of his colleagues in the Ohio Wildlife Research Unit, Dr. D. L. Leedy and Mr. E. E. Good, who read the manuscript and offered suggestions for its improvement. Particular thanks are due his wife, Christine K. Dambach, for the laborious task she performed in checking dates and length of open seasons presented in Chart 1.

Data from the above sources and from U. S. Census Reports (1, 2) were used in the compilation of a Chronological Record of hunting and trapping restrictions in Ohio (Chart I and Figs. 1, 2, 3, 4), and land use changes which effect wildlife populations (Figs. 5, 6). Although the regulations are believed to be essentially correct as presented, some errors may have occurred in interpreting which of the many laws passed in a single legislative session actually were later enforced.

CHRONOLOGICAL RECORD OF WILDLIFE-USE RESTRICTIONS IN OHIO

Protecting man from wildlife.

Laws regulating the use of Ohio's wildlife resources pre-date its statehood. Before 1800 settlers sought protection of themselves and their property from wild animals by the provision of a bounty to encourage the killing of predatory animals and safeguarded the right of all persons to use fire arms for "killing or destroying any wild animals" (Laws of the Northwest Territory, 1790, 1799). Protecting man and his property from wildlife was the primary objective of nearly all legislation concerning wildlife during the period between 1790 and 1857. Most of the laws passed concerned the payment of bounties to encourage the killing of wolves panthers, hawks, and for one biennium, squirrels. The latter law, promulgated in 1807, made it mandatory that each person subject to payment of a county tax "shall in addition thereto, produce to the clerk of the township in which he may reside, such number of squirrel scalps, as the trustees shall, at their annual meeting apportion, in proportion to their county levies, provided that it does not exceed 100 nor be less than 10" (Ohio Laws, 1807).

A penalty of three cents a scalp for the number not turned in was authorized. Although this law was repealed at the next session of the legislature (Ohio Laws, 1809) it is indicative of the attitude of man toward the fauna of his newly invaded environment. Whether or not he succeeded in subduing wild animals through use of the axe which changed the environment or the use of the gun which the bounty encouraged is an important point to consider in our present efforts to manage wildlife for man's benefit. Several other important points are, however, clear from these early records:

1. Game useful to the early settlers and the resident Indian population was present in sufficient abundance in relation to need that no legal effort was made to conserve the supply.
2. Some species of *forest inhabiting* wildlife were present in such numbers as to destroy mans livestock and crops leading him to seek legislative means of protection. Predatory animals were the chief objective of this action.
3. Game animals and their natural predators were abundant at one and the same time.

Protection of wildlife from man.

Although some bounty laws intended to protect personal property from wildlife damage are still in force, they are now of relatively minor significance compared to laws designed to protect wild animals from destruction by man. The first of the latter laws in Ohio was passed in 1829 to safeguard the fur trade. It provided "that if any person shall, between the first of May and the 15th of October following, kill or destroy any muskrats and be thereof convicted—he shall forfeit and pay one dollar for each muskrat—except—where muskrats are destroying property", (Ohio Laws, 1829.) This law was later amended to further protect the fur trade in the Lake Erie counties by extending the closed season and including also the beaver, marten, mink and otter as species to be protected (Ohio Laws, 1833, 1840, 1843).

Apparently little concern was felt for other fur bearing or game species until about 1857. In that year closed seasons were established to protect the bob-white quail, deer, dove, ducks, flicker, geese, prairie chicken, rabbit, ruffed grouse, wild turkey and woodcock. Complete protection throughout the year was provided for certain songbirds, namely: sparrow, robin, bluebird, martin, thrush, mocking bird, swallow, redbird and catbird. In the immediately succeeding years addi-

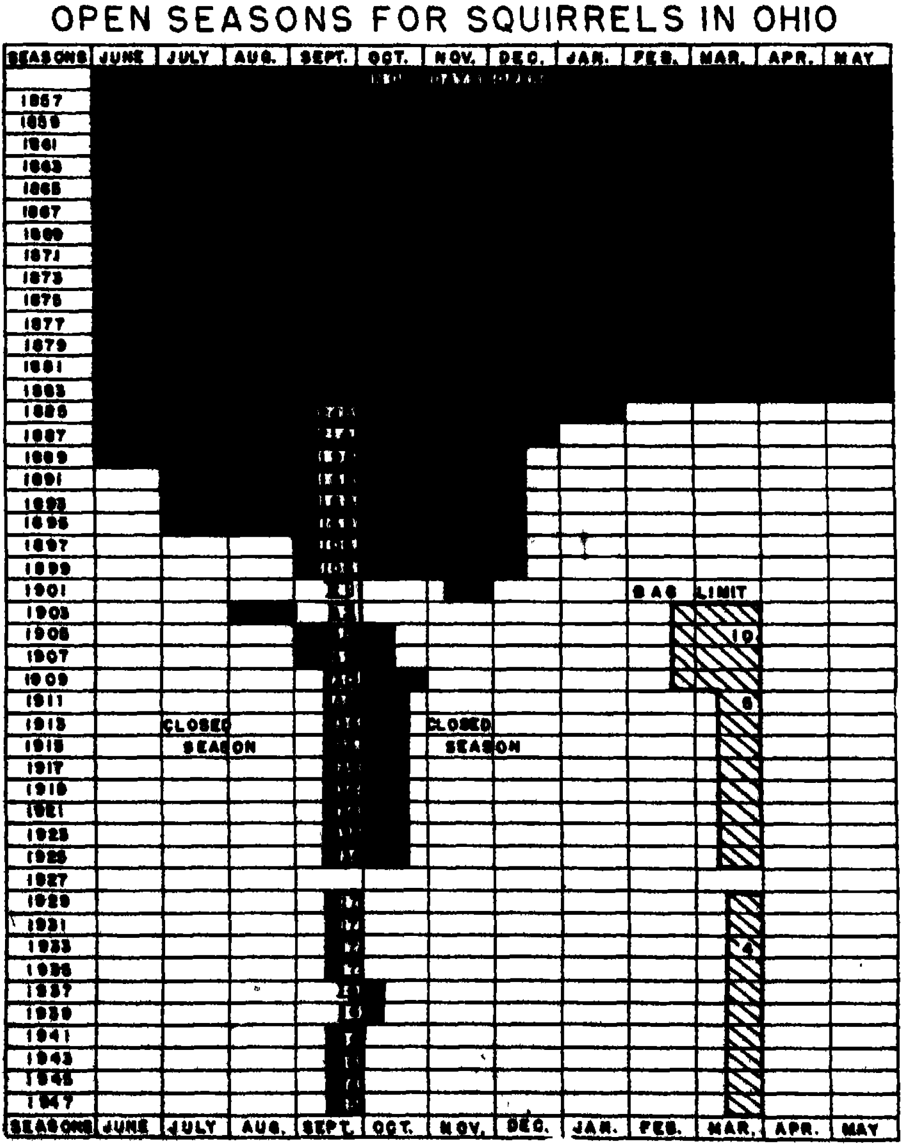

FIG. 1. Open seasons for squirrels in Ohio. Grey and fox squirrels were among the last of Ohio game species to receive the protection of closed seasons. Protection was first given them in 1885 when a 245-day open season was declared. Subsequently the open season was drastically reduced, closed for one year, and augmented by a bag limit which now stands at four per day. This is a marked change from the Ohio law in 1807 which made it mandatory that squirrels be killed.

tional species were given some degree of protection and the closed season was progressively lengthened. (Chart I.)

By 1885 nearly all of our important game and fur bearing species were afforded partial protection and most song and insectivorous birds were completely protected. Providing protection during the breeding season alone was not considered an adequate measure to halt the apparent decline of wildlife in relation to demand. The Legislature early sought other means of coping with the problem. One of these measures was to prohibit all hunting of endangered game species for one or more years in order that they might recover. Hunting of quail, for example, was prohibited in Fulton county for a five year period beginning in 1885. Deer hunting was banned for a four year period beginning in 1896, a ban which subsequently was extended to 1943 when the state had its first legal deer season in nearly fifty years. Similarly, quail and doves were given a rest period in 1913 but later, apparently because they did not respond to protection they were classed as song birds thus removing them from consideration as game species.

The addition of a bag limit to the complex of wildlife use restrictions in 1902 is indication that the legislators were thinking of an equitable distribution of the game crop as well as safeguarding the species. Bag limits like open seasons however became progressively smaller in succeeding years. They were augmented from time to time by new regulations designed to limit the method by which animals could be taken, to limit the number held in possession, to prohibit the sale of wild animals and still more recently to limit the hours of the day during which they can be taken. A few examples of these measures are the outlawing of the use of ferrets in hunting rabbits, the three shell limit in hunting waterfowl, prohibiting baiting and use of live decoys in waterfowl hunting, delaying hunting on the opening day of the season until noon and the most recent restriction in Ohio of limiting hunting to the hours between 9:00 a.m. and 4:00 p.m..

Development of public interest in wildlife conservation.

More than 85 years elapsed between the time the first laws affecting wildlife were passed in the state and the appointment of an official body to enforce them. During this interim game laws were enforced, if at all, by local officials. One of the earliest enforcement problems dealt with the rights of landowners to hunt without restriction upon their own property. This right was upheld by law for rabbits and doves up to 1865 and for rabbits only until 1874. Although the right to regulate the use of resident wildlife on all lands is now clearly vested in the state (Ohio Laws, 1919) there is still evidence of non-compliance particularly in remote areas.

The first official body in the state to deal with these and other wildlife conservation matters was a three-man Ohio Fish Commission created by an act of the Legislature in 1873. Its duties were largely concerned with investigation and recommendation. A new five-member commission, called the Commission of Fish and Game, was appointed in 1886. The law establishing the new commission provided among other things that: the Governor by and with the consent of the Senate shall appoint five Commissioners of Fish and Game, of whom no more than three shall belong to the same political party, one for one, one for two, one for three years and so on and who shall be subject to removal at the governor's pleasure. It further provided for the appointment of fish and game wardens to enforce the fish and game laws. These wardens were to be appointed from the political party polling the most votes in the previous gubernatorial election.

New commissions were subsequently appointed under the terms of this act until 1913 when the Legislature replaced it with a Fish and Game Division within the State Board of Agriculture. A seven-member Advisory Board was appointed in 1923 to assist the new Division in developing a policy and a program of action. Another major change took place in 1929 when the Legislature abolished the Division of Fish and Game and created a Division of Conservation headed by a commissioner who was appointed by the State Director of Agriculture. A council of 8 members appointed by the Governor for four year terms was established to guide the program of the new Division. Ten years later the present Division of Conservation and Natural Resources was established by legislative action. A nine-member commission appointed by the Governor employs a commissioner who is charged with responsibility for carrying out the program and policies deter-

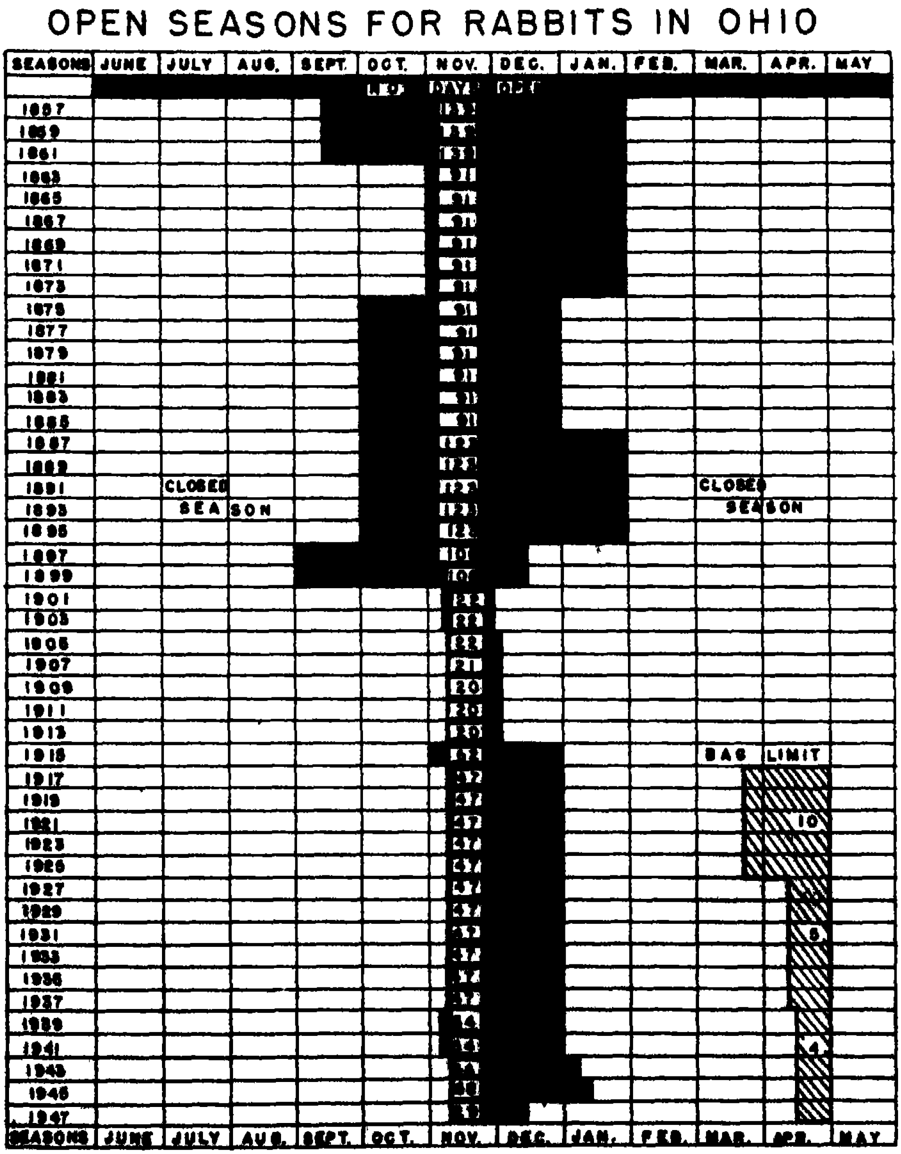

Fig. 2. Open seasons for rabbits in Ohio. Cottontails have been protected by closed seasons in Ohio since 1857 and by a bag limit since 1917. It is of especial interest to note that the shortest seasons in the State's history occurred at the turn of the century when urban population was greatly increasing and when woodland area on farms was rapidly being depleted.

mined by the commission. The commission is bi-partisan, composing not more than four members of the same political party. The ninth member, the State Director of Agriculture, serves on the commission but has no vote in matters concerning personnel. Terms of the commission members who serve for eight years are staggered so that it is unlikely that any one governor may appoint a majority of its members.

The over-all objective of these changes has been to broaden the responsibilities of the state with respect to its wildlife resources and to make more effective its law enforcement efforts. Both the Conservation Commission and the former Conservation Council were vested with authority to issue and enforce fish and game regulations (Section 1390, General Code of Ohio). The present Commission thus is directly charged with responsibility for providing that the wildlife crop is equitably harvested and that it is perpetuated.

Effectiveness of Game Laws in Perpetuating Wildlife Resources.

The majority of the personnel hired by the various conservation commissions in Ohio as in other states have been used to enforce regulations passed by the Legislature or by Commission Order. The effectiveness of these regulations is considered in the sections to follow:

Forest Wildlife

The principal forest game species in Ohio were the Virginia white-tailed deer (*Odocoileus virginianus virginianus*), the grey squirrel (*Sciurus carolinensis*), the eastern ruffed grouse (*Bonasa u. umbellus*) and the eastern turkey (*Meleagris gallopavo silvestris*). All of these species were reputed to have been very abundant in the State at one time. Except for the grey squirrel they have all been protected by progressively longer closed seasons since 1857 and in more recent years by bag limits (Chart I). It is significant that both the white-tailed deer and the wild turkey were extirpated from the State despite the protection afforded them and that extirpation resulted 9 to 15 years after they were supposed to be protected by complete closed seasons.

Squirrels which in 1807 had to be killed to avoid a tax penalty were not given any protection until 1885. The precipitous rate at which the open season was shortened thereafter and the enforcement of a strict bag limit apparently did not halt the decline of these animals (Fig. 1). Similar trends were experienced for other forest game species such as the raccoon (*Procyon lotor*).

The rapid decline of forest wildlife species was in proportion to the decline in total forest area and woodland area per farm and inverse to the rise of human population in the state. (Figs. 5 and 6.) The rate of decline however apparently slackened or was arrested before the rise of the heavy gun-pressure which now characterizes our hunting seasons. This is evident from the fact that open seasons on present forest wildlife have been somewhat relaxed during the past decade. Two species, for example, the ruffed grouse and the now reintroduced white-tailed deer are increasing in number and a third, squirrels, are apparently at least holding their own.

The most logical explanation for this phenomenon is to be found in the amount of land in the state abandoned, in recent years, for agricultural use and in various stages of forest succession. Leedy (8), in a companion paper has pointed out that during the "first 40 years of the present century the number of farms in the southeastern third of Ohio dropped from 86,759 to 73,073 and the land in farms from 8,148,134 to 6,949,919 acres". Most of this land is at present in a stage of plant succession more favorable to deer than the original unbroken forest. As the succession moves on to more mature forest conditions for grouse and squirrels should improve.

Fur bearing animals.

Interest in the welfare of fur bearing animals, other than the beaver, marten, mink, muskrat and otter was not reflected in hunting restrictions until after 1900. Restrictions on the forest inhabiting raccoon as on the squirrel rapidly became more severe soon after their introduction while those on the more adaptable foxes fluctuated greatly from season to season in probable response to competitive lobbying by farm and fox hunter interests. Both grey and red foxes markedly

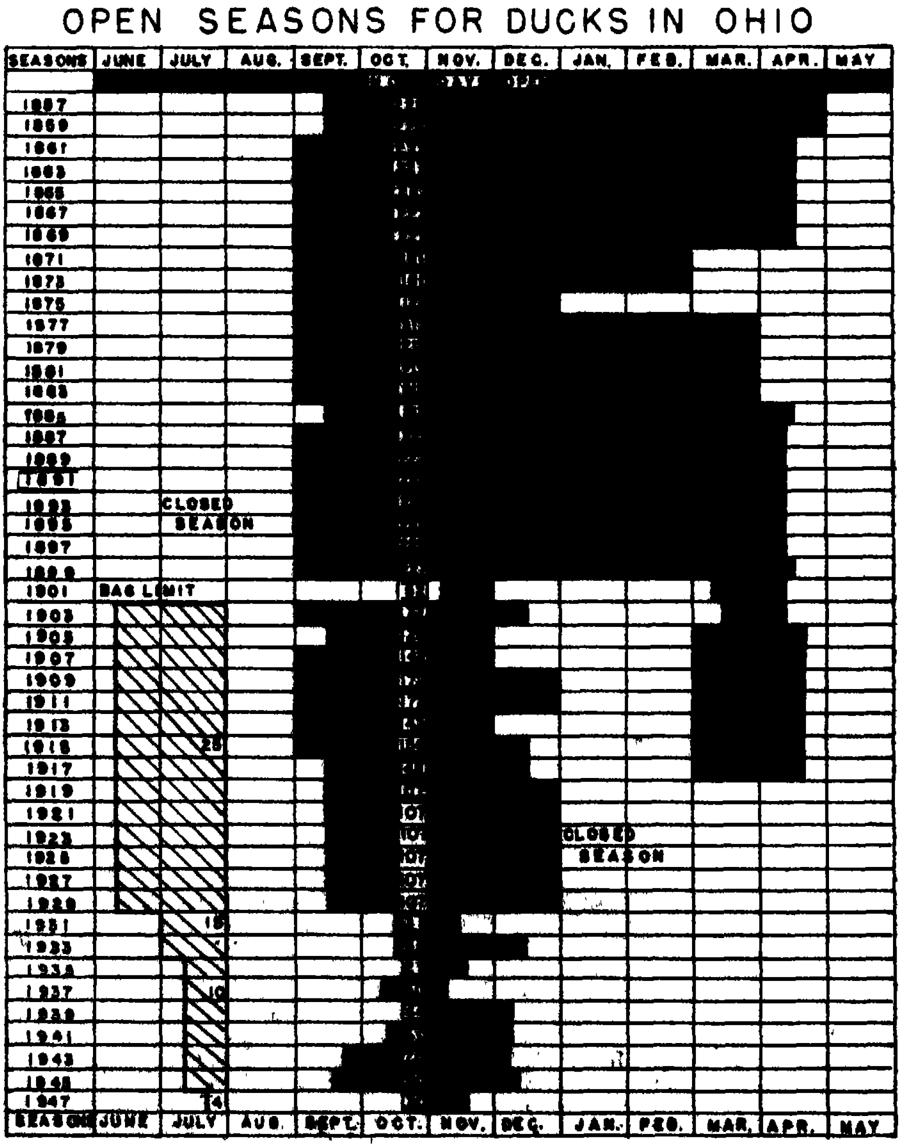

FIG. 3. Open seasons for ducks in Ohio. Restrictions on waterfowl hunting have varied greatly since they were first established in 1857. The lowest ebb in the waterfowl population occurred during the early 1930's when the season was reduced to 30 days. It was subsequently raised in response to improved reproductive conditions despite constantly rising gun pressure. The season has again been drastically lowered because of poor reproduction and a great postwar increase in hunting pressure.

increased in recent years despite the removal of the closed season protecting them and the enactment of a bounty law in 1945 to encourage their slaughter. They have decreased sharply however since 1946.

The trend of restrictions applied to muskrats is a remarkable indicator of population changes in response to environmental alterations. (Fig. 4). This was the first animal to be afforded the protection of a closed season in the state. In some counties where it is now wild-trapped on a commercial scale (Huron, Lucas, Ottawa and Sandusky counties) the trapping season was reduced to but 60 days in 1840 or approximately one-half the present open season in the same area. (Chart I). For the entire state the open season on these animals is now about 20 days longer than it was during the period between 1867 and 1911. The annual fur harvest in the state indicates that many more muskrats are trapped now by more trappers than at any previous time. It also indicates that the number of muskrats pelted fluctuates from year to year largely in response to economic inducement, favorableness of the trapping season and natural factors not now fully understood.

Explanation for the general increase in the annual muskrat crop during modern times can best be found in a great increase of habitable environment. Impounded water in Ohio which has resulted from flood control, water storage and recreational developments is now more than 1,000 percent greater than at the time of settlement. Muskrats occupy most if not all of these large impounded areas. They have also benefited greatly from the thousands of miles of open drainage ditches in the level agricultural regions of the state. These ditches provide both good sites for muskrats homes and an abundance of superior foods such as corn, soybeans and leguminous forage plants which grow in the nearby crop fields. More than 100 muskrats per mile of drainage ditch have been harvested on an annual basis in some of the more productive areas of the state. Drainage ditches which now exceed natural streams in the state in total length are much more productive of muskrats per unit of area or length than virgin streams that flowed through wooded areas.

Fluctuations in the number of other fur bearers is not so readily explained. There is evidence however that some species, notably beaver and otter became or nearly became extirpated despite early legal action for their protection. It is interesting to note that beaver are becoming reestablished in a number of eastern Ohio counties where considerable land has been retired from agricultural use. These colonies, it should also be noted, probably could not persist without protection from disturbance afforded by local game protectors. The latter thus are able to protect brood stock established through favorable environmental changes.

Migratory wildlife.

Ducks, geese, swans, woodcock, doves and other migratory game birds have been afforded protection during their nesting seasons in Ohio since 1857. (Fig. 3 and Chart I). During this period the restrictions in effect have undergone extreme fluctuations at irregular intervals. It is probable that these changes reflect fluctuations in the supply of waterfowl due to environmental conditions such as recurrent drouths. This is known to be the case during the early 1930's when the North American population of these birds reached an all time recorded low of around 23,000,000 individuals.

Waterfowl and most shore birds are particularly subject to decimation by hunting because of their gregarious behavior during migration and the limited suitable habitat available to them for resting or feeding during this period. It is interesting to note, however, that further restrictions on the waterfowl hunting season in 1946 were made in response to a drop in the duck population that occurred while hunting pressure was at its lowest ebb in recent years due to war conditions. Despite the shortened open season and reduced bag limit the population dropped still farther before 1947, resulting in an open season reduced to but 30 days and a bag limit of 4.

Woodcock are more generally distributed and subject to far less gun pressure during the hunting season than are waterfowl. According to Leedy (7) only 3.6 percent of Ohio hunters pursued this bird during the 1947 season as compared to 9.1 percent who hunted ducks. The population of these birds, however, has apparently continued to decline despite progressively tightened restrictions on

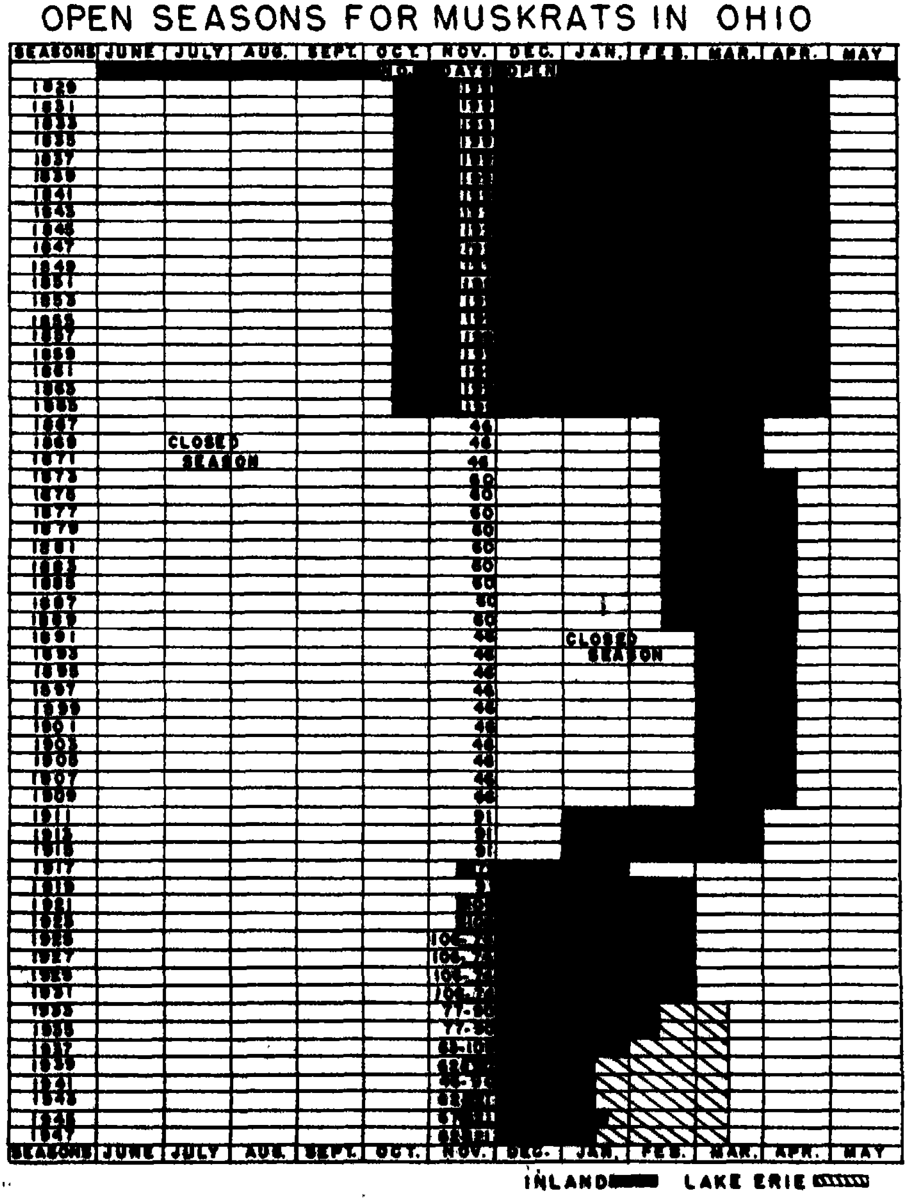
OPEN SEASONS FOR MUSKRATS IN OHIO

FIG. 4. Open season for muskrats in Ohio. The muskrat has been protected in Ohio for nearly 120 years. We now enjoy a longer trapping season with more pelts being taken annually than was true during the period between 1867 and 1915. This change is probably due to a great increase in habitable muskrat range resulting from improvements for agricultural use of the land such as open drainage ditches and water impoundments for flood control, water storage and recreational purposes.

their use. A similar trend characterizes the population of other shore birds (Chart I). Most of these had reached such low population levels by 1931 that they were then given completely closed seasons. They have not since recovered sufficiently to justify even a very limited open season.

Many words have already been written decrying the wanton slaughter of passenger pigeons in Ohio and elsewhere by market hunters. It is generally believed that such hunting led to their extinction in 1919. It is not so well known, however, that in Ohio at least these birds were protected from market hunting by a law passed in 1876 which made it unlawful to "take or destroy wild pigeons in roosting places, or to discharge firearms within one-half mile of same". This law was further strengthened in 1886 by a measure which forbid "disturbing of pigeons, their eggs or nestlings on their nesting grounds or roostings". Mass slaughter of these birds thus was made illegal more than 25 years before the last record of a bird being killed in the state and more than 40 years before the species passed into oblivion. Restrictions thus may have delayed their final demise but certainly did not prevent it.

The history of most vanishing species in this country reads like a sequel to the story of the passenger pigeon. Nearly all of them were afforded some degree of legal protection when their numbers began to diminish greatly. Fortunately, the extinction of some species has apparently been temporarily, at least, averted (trumpeter swan, whooping crane, ivory billed woodpecker). Those which have recovered have done so under the combined stimulus of protection from hunting and provision of their needed environment.

Recovery of the American elk, the pronghorned antelope, and the colonial nesting birds like the snowy egret, wood ibis, Florida crane and others are stirring examples. It would be well, in the light of these facts, to temper condemnation of the hunter as the decimator of formerly abundant wildlife with the knowledge that much of the wildlife he destroyed could not now survive due to agricultural and industrial progress, except in special preserves or refuges. These facts do not, however, in any manner lessen the importance of hunting restriction enforcement as a tool in perpetuating wildlife species. We need only refer to the recovery of the fur seal industry following the international treaty for their protection in 1911 for evidence that protection from hunting beyond the harvestable surplus is necessary even if other suitable environmental factors are favorable.

Resident Farm Game.

Farm game is probably considerably more abundant in Ohio now than it was 150 years ago. The two principal species in this catagory, at present, cottontail rabbits and ringnecked pheasants, provide millions of hours of recreation and millions of pounds of meat to Ohio hunters annually (9). That cottontails have long been held in high esteem by Ohio hunters is evident from the fact that they were afforded the protection of a fairly long closed season (225 days) as early as 1857 (Fig. 2) and subsequently were favored with special restrictions to enhance their welfare. These included prohibiting the use of ferrets, introduction of a bag limit, and prohibiting the sale of legally taken rabbits.

Changes in length of the open season on Ohio cottontails exhibit a somewhat cyclic pattern (Fig. 2). Whether these changes reflect population variations due to hunting pressure, disease or adverse climatic conditions can only be surmised at the present time. It is evident however that whatever the cause cottontail populations have so improved that we have, in recent years, enjoyed a longer open season on them than was permitted half a century ago. The increase in the length of the open season, it should be noted, came at a time when hunting pressure was rising in response to social changes and has been sustained through at least two decades of intense gun pressure. It may be argued that the lengthened open season was made possible through introduction of a bag limit in 1902. Although this

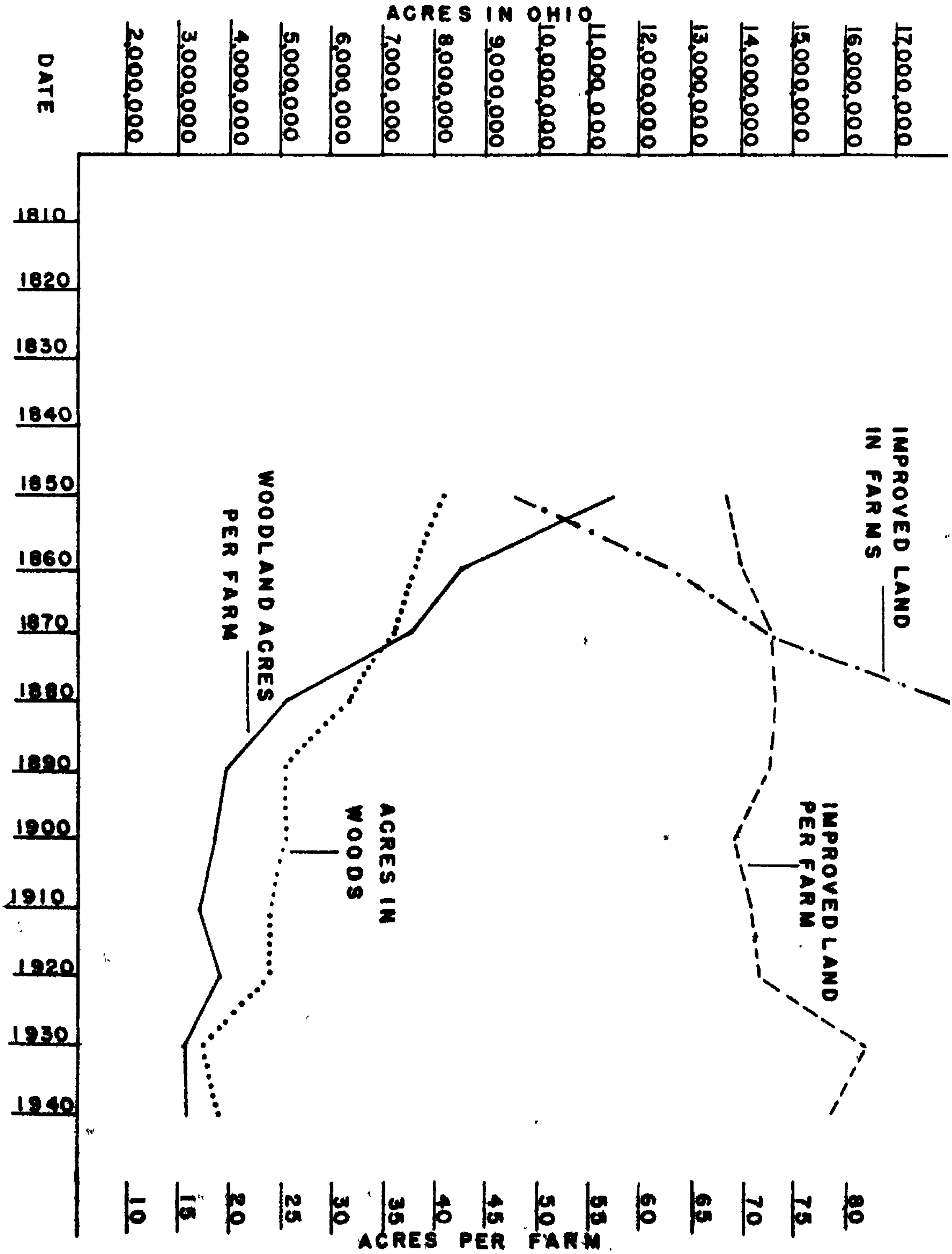

FIG. 5. Changes in Ohio land use.

may be a contributing factor it appears more logical to the writer that the change is due to land use practices such as the growing of forage crops on once forested land.

Ringnecked pheasants, although not introduced successfully into the state until 1896 (5), have also responded well to agricultural use of the land. They too greatly increased in number in the face of rising gun pressure and it is believed for the same reason offered for cottontails.

Our other exotic game bird, the European or popularly called Hungarian partridge has had a less successful history than the pheasant. It has declined in the state to such a low ebb that it has been given complete protection. It is very doubtful however that hunting had much to do with the decline of this bird which is a notoriously difficult target for even the experienced hunter. The European partridge, like the ground nesting cottontail rabbit, ring-necked pheasant and bob-white quail suffered from unfavorable reproductive conditions during the peak nesting period of several recent years.

Of special interest is the fact that the sharp decline of these three species occurred at a time when hunting pressure was at a low ebb with fewer hunters in the field for less time and with less ammunition to expend than usual, due to war conditions. Now that hunting pressure is at an all time high (Fig. 6) the length of the open season has been drastically curtailed to meet the situation. In the meantime we have been favored by a successful breeding season during which both cottontails and pheasants have remarkably recovered to some where near their pre-war abundance. Field studies indicate that the current increase is largely a function of more successful reproduction than occurred during the unfavorable years previously mentioned.

No discussion of farm game in Ohio would be complete without reference to the bob-white quail which has been the subject of a controversy between sportsmen, farmers and nature lovers since it was protected by a closed season and especially since it was made a song bird in 1917. Although the quail, like the cottontail and pheasant, benefitted from early agricultural use of our once forested land it apparently has not been able to hold its own under the more intensive type of agriculture now practiced—particularly in the northwestern part of the state.

Quail have long been protected in this state by favorable closed seasons and special restrictions (Chart I). Their number, nonetheless declined to such an extent that a closed season seemed to be in order before hunting pressure reached the point that a resident hunting license law was put into effect. There is no evidence that quail have responded to this protection. They still experience drastic population slumps in response to unfavorable climatic conditions such as prolonged periods of deep snow cover. The severe winters of 1935–36 and 1944–45 are good examples. Prior to both of these winters Ohio Quail populations had attained fairly stable levels for a number of years. During the severe weather which followed their numbers dropped to a fraction of their average density. It has been observed by this winter that quail populations in Ohio are about the same as those in neighboring states in comparable range and where hunting is permitted. It has also been observed that their populations fluctate to the same degree when similar weather conditions are experienced.

Land use and social changes in relation to wildlife populations.

One of the most obvious social changes affecting wildlife numbers is the change in density and character of the human population. There were less than a million persons in Ohio when the first law protecting a wild animal was passed. At that time 96 percent of the total population lived on farms. Twenty-eight years later, in 1857, the population had more than doubled and at least one of every six persons was living in a city. It was at this time, with a population density of one person per 12 acres in the state that the Legislature took serious cognizance of the welfare

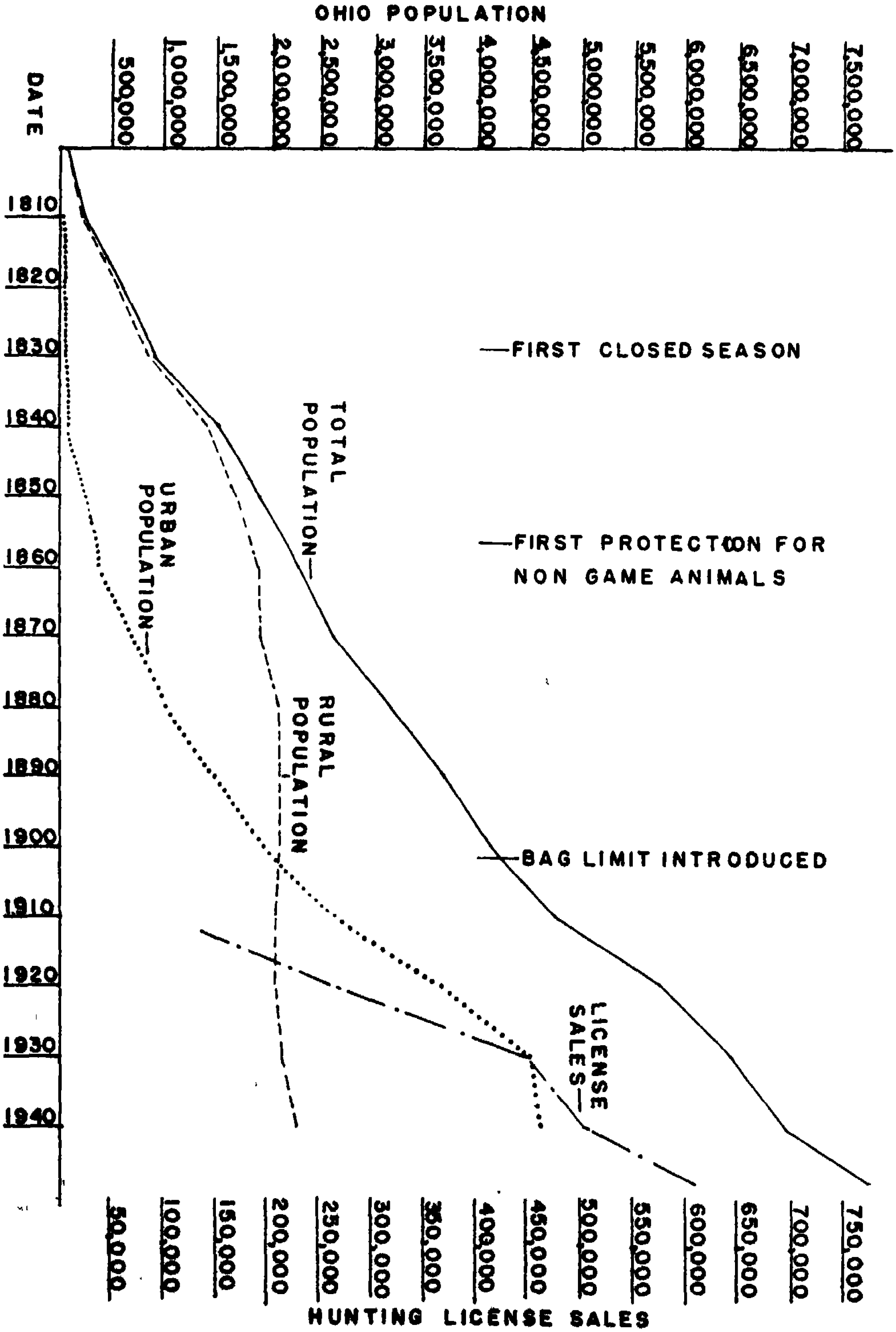

Fig. 6. Ohio population growth, game laws and license sales.

of wildlife and afforded protection to both game and non-game species. Prior to this time there was little inducement for market hunting of wildlife.

The advent of improved transportation facilities following World War I made it possible for many city dwellers to spend an occasional day in the field in pursuit of game thus adding, for the first time, the pressure of city hunters to that exerted by the relatively stable farm population. Growth in the sale of hunting and fishing licenses clearly indicates the rapid trend in this movement. The first resident hunting license law in the state was made effective in 1913. During that year less than 150,000 of the state's nearly 5,000,000 residents, or one in 33, purchased a license to hunt. Hunting license sales since that time have, except for temporary declines due to economic conditions or the recent national emergency, increased at a more rapid rate than population growth. (Fig. 6.)

In recent years hunting license sales have risen to between 600,000 to 700,000 per annum or an average of one license sale per 10 residents or one license per 30 acres of huntable range. These figures do not take into account landowners, farm operators or their children who are permitted to hunt without a license on the land they own or operate. Together these groups probably aggregate nearly a million hunters annually. This represents enormous pressure both on the wildlife and the land that sustains it. Most of this pressure, it should be noted, comes from the urban segment of the population since farm units and farm population have changed little since hunting licenses have been issued. The approximately 250,000 farm units in Ohio today probably sustain three times the hunting population they were subjected to before transportation made it possible for the urban hunter to freely take part in this sport.

Explanation for the rise in the number of persons who seek recreation in the form of hunting may not all be attributed to population growth. Part of it is, of course, due to the desire of men to seek refuge from the complexities of urban life by a few days afield. Opportunity to fulfil this desire has been greatly favored by higher income which has made ownership of transportation facilitites within the means of the average man, shorter working days and short work weeks and the provision of vacations which are part of modern employment practice. Advertising too has surely had an influence on the increasing proportion of our population that hunts or fishes or both. The manufacturers of hunting and fishing equipment have done much to encourage people to participate in these sports through their advertizing in outdoor magazines. This has proved to be a profitable enterprise as these companies and various other businesses profit from the business use of wildlife creates. In Ohio alone expenditures for hunting and fishing have aggregated in excess of $60,000,000 per annum in recent years (9). Even state conservation departments have felt it necessary to advertise their wildlife crop in order to sell more licenses in the interest of securing revenue with which to carry on their work.

We are thus faced with a situation in which social changes are leading to increased hunting pressure without increasing capacity of the land to produce the crop to be harvested. Most of the huntable land in Ohio is in farm ownership where the production of wildlife is at best an incidental and often undesired crop. The public land available for hunting in the state would provide but a fraction of an acre per license holder and is thus of no material consequence, at least at present.

"The ownership of, and title to all wild animals in the State of Ohio, not legally confined or held in private ownership legally acquired,—is in the State, which holds it in trust for the benefit of all the people" (Section 1391, Ohio General Code). Although this law is universally accepted in the United States it has created problems which make the management of wildlife, particularly on private lands, a difficult venture. Under its terms the manufacturer who profits from the sale of hunting equipment may exploit this resource through encouraging hunting with his equipment without doing anything to maintain the resource while the hunter may use his equipment to harvest game he likewise did nothing to produce. The right of the individual to use wildlife is thus guaranteed but with this right there is no legal responsibility, except obeying game laws, and little moral recognition of responsibility for its welfare. The State on the otherhand is charged with responsibility for the welfare of wildlife but has little opportunity to exercise it because wild life is produced primarily on lands managed for agricultural purposes. It is then, the land owner or farmer who has the opportunity to provide for the welfare of wildlife through his management of the land. Unfortunately there is little incentive for him to do so.

Under these circumstances it is but natural that the states have resorted to managing their wildlife largely by dividing the crop as equitably as feasible through enforcement of game laws. Although these efforts appear to have been fairly effective in dividing the crop it is clear that they have little to do with producing it. This is true of many other activities of conservation departments in which they engage in an effort to find some means of benefitting wildlife with the funds at their disposal. In our own state for example the Conservation Division expended but a little over $600,000 for operations which include wildlife management of the land (of which only a small percent was for private land) as compared to nearly $500,000 for law enforcement, nearly $300,000 for artificial propagation, nearly $150,000 for public relations and nearly $200,000 for administration out of a total budget of $1,779,000 (10). Even had the entire budget been available for activities on private land it would represent an expenditure of but a few cents an acre for this purpose.

CHART 1

CHRONOLOGICAL RECORD OF CHANGES IN HUNTING AND TRAPPING* RESTRICTIONS IN OHIO FOR PRINCIPAL GAME SPECIES

Year	Species	Bag Limit	Open Seasons	Length of Open Seasons
1829	*Muskrat*	....	Oct. 15–May 1	199 days
1833	*Marten*, *mink*, muskrat, *otter*—Huron Co.	....	Dec. 1–April 1	122 days
1840	*Beaver*, marten, mink, muskrat, otter—Lucas and Ottawa Counties	....	Feb. 1–April 1	60 days
1845	Sandusky County added to above	....	Feb. 1–April 1	60 days
1857	*Dove*, *flicker*, *grouse*, *prairie chicken*, *quail*, *turkey*, *woodcock*, *deer*, *rabbit*	....	Sept. 15–Feb. 1	140 days
	Geese, *duck*	....	Sept. 15–May 1	229 days
	Bluebird, *catbird*, *martin*, *mocking bird*, *red bird*, *robin*, *sparrow*, *swallow*, *thrush*		Protected at all times	None
1861	Deer, grouse, prairie chicken, turkey	....	Sept. 1–Feb. 1	154 days
	Killdeer, *meadow lark*, quail	....	Oct. 1–Feb. 1	124 days
	Geese, duck	....	Sept. 1–April 15	227 days
	Woodcock	....	July 4–Feb. 1	213 days
	Bobolink, *creeper*, *cuckoo*, *finch*, *ground robin*, *indigo bird*, *kingbird*, *nuthatch*, *oriole*, *pewee* or *phoebe*, *warbler*, *yellowbird*	....	Protected at all times	None
1864	Deer	....	Sept. 15–Dec. 1	78 days
1865	Dove, rabbit (except on premise of hunter)	....	Nov. 1–Feb. 1	93 days
	Grouse, prairie chicken, quail, turkey	....	Oct. 15–Feb. 4	113 days
1866	Deer	....	Oct. 1–Jan. 1	93 days

*Names of birds common to the European countries were included despite the fact that there were no records of their having been recorded here. Probably some of these names were applied in the early days to our native birds.

Italics indicate the first time protection was afforded a species. Only significant changes in length of season and/or bag limit are recorded.

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1867	Grouse, quail		Oct. 15–Feb. 1	110 days
	Mink, muskrat, otter		Feb. 15–April 1	46 days
	Flicker, wren		Protected at all times	None
1871	Duck		Sept. 1–Mar. 1	182 days
1873	Deer		Nov. 1–Jan. 1	62 days
	Mink, muskrat, otter (on premises of another)		Feb. 15–April 15	60 days
1874	Deer		Oct. 1–Dec. 1	62 days
	Pheasant or ruffed grouse, prairie chicken or pinnated grouse, *blue-winged teal*, *mallard* or *wood duck* or any other wild duck, wild goose, or brant		Sept. 1–Jan. 1	123 days
	Quail, turkey		Oct. 15–Jan 1	79 days
	Rabbits (on premises of another)		Oct. 1–Jan. 1	93 days
	Crossbill or corncrake,* dummock,* Eur. blackbird,* great tit* or *blue tit,* grossbeak, hedge sparrow,* Hungarian robin,* nightingale,** redstart		Protected at all times	None
1875	Deer		Nov. 1–Dec. 1	31 days
1876	Bl.-wg. teal, ruffed grouse		Sept. 1 Jan. 1	123 days
	Deer		Oct. 15–Dec. 1	48 days
	Mallard or wood duck or other wild duck		Sept. 1–April 1	213 days
	Quail, turkey		Nov. 1–Jan. 15	76 days
	Woodcock		July 4–Jan. 1	182 days
1877	Deer		Sept. 20–Nov. 1	43 days
	Quail or prairie chicken		Nov. 1–Jan. 1	62 days
	Swan		Protected at all times	None
	Turkey		Nov. 1–Jan. 15	76 days
1879	Deer		Oct. 20–Nov. 20	31 days
1883	Deer		Oct. 15–Nov. 20	37 days
	Quail, prairie chicken		Nov. 1–Dec. 1	31 days
1885	Quail		Closed in Fulton Co. for 5 years.	None
	Mallard or wood duck		Sept. 1–April 1	213 days
	Other wild duck		Sept. 15–April 15	213 days
	Gray or *fox squirrel*		June 1–Feb. 1	246 days
1886	Mallard, wood and other ducks		Sept. 1–April 10	225 days
	Quail or prairie chicken		Nov. 10–Jan. 1	53 days
	Rabbit		Oct. 1–Feb. 1	124 days
	Squirrel		June 1–Jan. 1	214 days
	Turtle dove		Aug. 1–Jan. 1	153 days
1888	Prairie chicken, ruffed grouse, any wild duck		Sept. 1–Dec. 15	106 days
	Quail		Nov. 10–Dec. 15	36 days
	Squirrel		June 1–Dec. 15	198 days
	Turkey		Oct. 1–Dec. 15	76 days
	Woodcock		July 15–Nov. 1	110 days
1890	Any wild duck		Sept. 1–April 10	222 days
	Deer		Oct. 15–Dec. 15	62 days
	Gray, fox or black squirrel		July 1–Dec. 15	168 days
	Mink, muskrat, otter		Mar. 1–April 15	46 days
1896	Deer, *ringnecked pheasant*		Closed to 1900	None
	Dove, rabbit, squirrel		Sept. 1–Dec. 15	106 days
	Rail		Sept. 1–April 10	222 days
	Ruffed grouse, turkey		Nov. 10–Dec. 15	36 days
	Woodcock		July 4–Nov. 15	135 days
1898	Duck		Sept. 1–April 15	227 days
1900	Coot, duck, rail		Nov. 10–Dec. 1 Mar. 10–April 10	22 days 32 days } 54 days
	Deer		Nov. 10–Dec. 16	37 days
	Prairie chicken, quail, rabbit, ruffed grouse, squirrel, woodcock		Nov. 10–Dec. 1	22 days

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1902	Pheasant, prairie chicken, ruffed grouse	*6*	Protected to Nov. 10, 1904; subsequently to 1917	None
	Rail		Nov. 10–Dec. 1 Mar. 10–April 20	22 days 42 days } 64 days
	Skunk		Nov. 1–Feb. 1	93 days
	Squirrel	*10*	Aug. 1–Sept. 1	32 days
	Turkey		Nov. 10–Dec. 1	22 days
	Woodcock	*18*	Aug. 1–Sept. 1	32 days
1904	Duck	*25*	Sept. 15–Dec. 1 Mar. 1–April 20	78 days 51 days } 129 days
	Geese, rail	*18*	Sept. 1–Dec. 1 Mar 1–April 1	92 days 32 days } 124 days
	Quail	*18*	Nov. 15–Dec. 15	32 days
	Rabbit		Nov. 15–Dec. 5	21 days
	Raccoon		Sept. 1–Mar. 1	182 days
	Squirrel	10	Sept. 15–Oct. 15	45 days
	Woodcock, dove	18	Sept. 1–Dec. 1	92 days
1906	Ducks	25	Sept. 1–Dec. 1 Mar. 1–April 20	92 days 51 days } 143 days
	Quail	18	Nov. 15–Dec. 5	21 days
	Rail	18	Sept. 1–Dec. 1 Mar. 1–April 20	92 days 51 days } 143 days
1908	Dove		Sept. 1–Dec. 4	95 days
	Ducks	25	Sept. 1–Dec. 31 Mar. 1–April 20	122 days 51 days } 173 days
	Quail	18	Nov. 15–Dec. 4	20 days
	Rabbit		Nov. 15–Dec. 4	20 days
	Raccoon		Nov. 1–Mar. 1	121 days
	Squirrel	10	Oct. 1–Oct. 30	30 days
1910	Rail	18	Sept. 1–Dec. 31 Mar. 1–April 20	122 days 51 days } 173 days
	Woodcock	12	Sept. 1–Dec. 4	95 days
1911	Deer, otter, prairie chicken, wild turkey		Reported extinct in Ohio.	
	Fox		Sept. 1–Dec. 1	92 days
	Muskrat		Jan. 1–April 1	91 days
	Quail	12	Nov. 15–Dec. 4	21 days
	Raccoon		Nov. 1–Mar. 1	121 days
	Squirrel	5	Sept. 15–Oct. 20	36 days
1913	Doves, quail, Hungarian partridge		Protected to 1915, then to 1917.	None
	Ducks and geese	25	Sept. 1–Dec. 1 Mar. 1–April 20	92 days 51 days } 143 days
	Fox		Oct. 1–Jan. 10	102 days
	Rail	12	Sept. 1–Dec. 1	92 days
	Skunk		Nov. 15–Feb. 1	79 days
1915	Duck	25	Sept. 1–Dec. 15 Mar. 1–April 20	106 days 51 days } 157 days
	Fox		Oct. 2–Jan. 9	100 days
	Rabbit		Nov. 1–Jan 1	62 days
	Rail	12	Sept. 1–Nov. 30	91 days
	Woodcock	12	Oct. 1–Nov. 30	61 days
1917	***Blackbird, bluejay, bobolink, buzzard, dove, eagle, gull, killdeer, mouse-hawk, nuthatch, quail, sparrow and other wild birds*** other than game birds		Made songbirds, protected at all times.	None
	Ducks	25	Sept. 16–Dec. 15 Mar. 1–April 20	91 days 51 days } 142 days

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1917	Hungarian partridge, rinknecked pheasant, ruffed grouse		Nov.15–Dec. 4	20 days
	Mink, muskrat, opossum, raccoon		Nov.15–Feb. 1	79 days
	Rabbit	10	Nov.15–Jan. 1	48 days
1919	Ducks	25	Sept.16–Dec. 31	107 days
	Fox		Oct. 2–Jan. 1	92 days
	Hungarian partridge	6	Nov.15–Nov.25	11 days
	Mink, opossum, raccoon, skunk		Nov. 1–Feb. 1	93 days
	Muskrat		Dec. 1–Mar. 1	91 days
	Rail	25 (Sora 35)	Nov. 1–Dec. 31	61 days
	Ringnecked pheasant	3 cockbirds	Nov.15–Nov.25	11 days
	Ruffed grouse	3	Nov.15–Nov.25	11 days
	Woodcock	6	Oct. 1–Nov.30	61 days
1921	Fox, opossum, skunk		Nov 15–Feb. 1	79 days
	Mink, muskrat		Nov.15–Mar. 1	107 days
1923	Raccoon		Nov.15–Feb. 1	79 days
1925	Muskrat		Inland, Nov.15–Mar. 1 Lake Erie, Dec. 1–Mar. 15	107 days 105 days
1927	Rabbit	5	Nov.15–Jan. 1	48 days
	Ruffed grouse, squirrel		Protected at all times	None
1928	Squirrel	4	Oct. 1–Oct. 15	15 days
	Yellowlegs		Protected at all times	None
1929	Fox		Nov.15–Jan. 1	48 days
	Squirrel	4	Sept.15—Oct. 1	16 days
	Woodcock	4	Oct. 15–Nov.14	31 days
1930	Rail	25 (Sora 25)	Nov. 1–Nov.30	30 days
1931	Ducks	15	Oct. 16–Nov.15	31 days
	Hungarian partridge	4	Nov.15–Nov.25	11 days
	Plover (black-bellied and golden)		Protected at all times	None
	Raccoon		Nov.15–Jan. 15	62 days
1932	Ducks	15	Oct. 16–Dec. 15	61 days
	Mink		Inland, Dec. 1–Feb. 15 Lake Erie, Dec. 1–Mar. 1	77 days 91 days
	Muskrat		Inland, Dec. 1–Feb. 15 Lake Erie, Dec. 15–Mar. 15	77 days 91 days
1934	Ducks	12	Oct. 4–Dec. 8	66 days
1935	Ducks	10	Oct. 21–Nov.19	30 days
	Fox		Nov.15–Feb. 1	79 days Southern counties, open elsewhere
	Mink		Inland, Dec. 1–Feb. 1 Lake Erie, closed	63 days None
	Rail	15 (Sora 25)	Nov. 1–Nov.19	19 days
1936	Ducks	10	Nov. 1–Nov.30	30 days
	Mink		Lake Erie, Dec. 15–Mar. 1	77 days
	Muskrat		Inland, Dec. 1–Feb. 1	63 days
	Rail	15 (Sora 25)	Sept. 1–Nov.30	92 days

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
	Ringnecked pheasant	2 cocks 4 possession	Nov. 15–Nov. 26	12 days
	Squirrel	4	Oct. 1–Oct. 15	15 days
	Woodchuck		Protected, March 1 to June 30	
1937	Ducks	10	Oct. 9–Nov. 7	30 days
	Mink		Lake Erie, Dec. 15–Feb. 1	49 days
	Opossum, skunk		Nov. 15–Jan. 15	62 days
	Squirrel		Sept. 25–Oct. 10	16 days
1938	Hungarian partridge	4	Nov. 15–Nov 30	16 days
	Mink, muskrat		Inland, Nov. 15–Jan. 15	62 days
			Lake Erie, Dec. 15–Mar. 15	91 days
	Rabbit	4	Nov. 15–Jan. 2	49 days
	Ringnecked pheasant	2	Nov. 15–Nov. 25	11 days
	Ruffed grouse	2	Nov. 15–Nov. 30	16 days
	Squirrel	4	Oct. 1–Oct 15	15 days
1939	Ducks	10	Oct. 22–Dec. 5	45 days
	Fox		Nov. 15–Jan. 15	62 days
	Hungarian partridge	4	Nov. 8–Nov. 30	23 days
	Rabbit	4	Nov. 8–Jan. 1	55 days
	Raccoon	6	Nov. 15–Jan. 1	48 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 8–Nov. 30	23 days
	Squirrel	4	Sept 25–Oct. 10	16 days
1940	Hungarian partridge	4	Nov 15–Nov. 30	16 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 15–Nov. 30	16 days
1941	Ducks	10	Oct. 16–Dec. 4	50 days
	Fox		Nov. 15–Feb. 1	79 days
	Mink, skunk		Dec. 1–Jan. 15	46 days
	Muskrat		Inland, Dec. 1–Jan. 15	46 days
			Lake Erie, Dec. 15–Mar. 15	91 days
	Raccoon	6	Nov. 15–Jan. 15	62 days
	Squirrel	4	Sept. 15–Sept. 30	16 days—southern
			Sept. 22–Sept. 30	9 days—northern
	Woodcock	4	Oct. 10–Oct. 24	15 days
1942	Fox		Nov. 20–Feb. 1	74 days
	Hungarian partridge	4	Nov. 20–Dec. 5	16 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 20–Dec. 5	16 days
	Muskrat		Inland, Nov. 20–Jan. 15	57 days
			Lake Erie, Nov. 20–Mar. 15	116 days
	Rabbit	4	Nov. 20–Jan. 5	47 days
1943	Deer (Restricted to Scioto, Adams and Pike Counties)	1 buck	Dec. 6–Dec. 18	13 days
	Ducks	10	Sept. 25–Dec. 3	70 days
	Hungarian partridge	4	Nov. 19–Dec. 4	16 days
	Mink, muskrat		Inland, Nov. 15–Jan. 15	62 days
			Lake Erie, Nov. 15–Mar. 15	121 days
	Rabbits	4	Nov. 19–Jan. 11	54 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 19–Dec. 4	16 days
	Skunk		Nov. 20–Mar. 15	116 days
	Wilson's snipe		Protected at all times	None

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1944	Deer	1 buck	Dec. 4–Dec. 9	6 days
	(Restricted to Scioto, Adams and Pike Counties)			
	Ducks	10	Sept. 20–Dec. 8	80 days
	(Bag limit also 5 mallards, pintails, widgeons, single or in the aggregate)			
	Hungarian partridge	4	Nov. 17–Dec. 2	16 days
	Mink, muskrat		Inland,	
			Nov. 17–Jan. 20	65 days
			Lake Erie,	
			Nov. 17–Mar. 1	105 days
	Opossum, skunk		Nov. 17–Jan. 20	65 days
	Rabbit	4	Nov. 17–Jan. 13	58 days
	Raccoon	2	Nov. 17–Jan. 20	65 days
	Red fox (in 14 S. E. Ohio Counties)		Nov. 17–Jan. 13	58 days
	Elsewhere open at all times.			
	Ringnecked pheasant, ruffed grouse	2	Nov. 17–Dec. 2	16 days
1945	Coot, merganser	25	Sept. 20–Dec. 8	80 days
	Deer	1 buck	Dec. 3–Dec. 8	6 days
	Ducks	10	Sept. 20–Dec. 8	80 days
	Geese	4	Sept. 20–Dec. 8	80 days
	Hungarian partridge, pheasant, rabbit.		Closed until 11 A. M. opening day	
	Mink, muskrat		Inland,	
			Nov. 15–Jan. 20	67 days
			Lake Erie,	
			Nov. 15–Mar. 15	121 days
	Opossum, raccoon, skunk		Nov. 15–Jan. 20	67 days
	Rails	15 (Sora 25)	Sept. 1–Nov. 30	91 days
	Woodcock		Oct. 10–Oct. 24	15 days
1946	Deer		Protected	None
	Ducks	7	Oct. 26–Dec. 9	45 days
	Geese	2	Oct. 26–Dec. 9	45 days
	Hungarian partridge	2	Nov. 15–Nov. 30	16 days
	Mink, muskrat		Inland,	
			Nov. 15–Jan. 15	62 days
			Lake Erie,	
			Nov. 15–Mar. 15	121 days
	Opossum		Nov. 15–Jan. 15	62 days
	Rabbit	4	Nov. 15–Jan. 1	48 days
	Raccoon	2	Nov. 15–Jan. 15	62 days
	Skunk		Nov. 15–Jan. 15	62 days
			Except in 18 S. E. Counties	None
	Squirrel	4	Sept. 14–Sept. 28	15 days
1947	Coot, merganser	25	Oct. 21–Nov. 19	30 days
	Deer (in 8 N. E. Counties)	1	Dec. 15–Dec. 20	6 days
	Ducks, geese	4	Oct. 21–Nov. 19	30 days
	Hungarian partridge, skunk		Protected	None
	Pheasant	2	Nov. 15–Nov. 22	8 days
	Rabbit	4	Nov. 15–Dec. 13	29 days
	Squirrel	4	Sept. 13–Sept. 27	15 days

DISCUSSION AND SUMMARY

Emphasis in this paper has been placed on the apparent natural decline and rise of certain game populations in the state in relation to the enforcement of hunting restrictions and land use and social changes. It has not been the writer's intent to minimize the importance of hunting restrictions but rather to point out their limitations in accomplishing the objectives for which they have been employed; namely perpetuation and increase of the species protected and sharing of the crop. The writer is convinced that regulations are necessary to assure an orderly and fairly distributed harvest of the wildlife crop but that their use should be tempered with recognition of their limitations of which the following are important examples:

1. Enforcement of hunting restrictions even to the extent of completely closed seasons has not been effective in halting the decline of wildlife suffering from habitat depletion. Most if not all wildlife declines in Ohio have been of this type. The history of deer, grouse, squirrels and wild turkey are examples.
2. The chief values of hunting restrictions appear to be:
   a. Preservation of brood stock. This is an assumed value as there is no clear evidence that hunting according to present custom is an effective means of reducing populations below their capacity to recover quickly *under favorable environmental conditions.* This is particularly true of species with a high biotic potential and the ability to seek refuge when pursued by the hunter. The cottontail rabbit in a brushy pasture is a good example. Unrestricted hunting might produce different results although the effect of diminishing returns from declining populations should tend to keep hunters out of the field.
   b. An equitable distribution of the supply of naturally produced wildlife. Limited open seasons and bag limits assure somewhat equal opportunity for the majority of hunters to be in the field at the same time in competition for the available crop.
3. The chief factor determining long time trends in game populations in Ohio is land use. Only in so far as the major use of the land can be modified to meet the needs of wildlife can any appreciable influence on game populations be expressed. Hunting restrictions, artificial propagation, predator control, winter feeding and related efforts are incidental compared to natural production. The land operator whether he be managing public or private land determines the use to which it is put. His use of the land can be modified to benefit wildlife if suitable incentives are provided. We do not at present seem to have any substantial means of providing these incentives.

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GALVANOTAXIS OF PARAMECIA: A STUDY THROUGH THE USE OF BALANCED SQUARE WAVES OF FREQUENCY THRESHOLDS IN RELATION TO CURRENT DENSITIES

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INTRODUCTION

Parmecia have been widely used for behavioral studies in the fields of animal and cellular galvanotaxis. However, in any quantitative study of living material a major problem has been to maintain all phases of the environment excepting for the one variable being studied. In previous papers (Goldston and Miller, 1947; Miller and Goldston, 1947) the authors have demonstrated the use of balanced square waves as a means of electronic stimulation. To this type of stimulation the test organism responds only to the direction of electron flow.

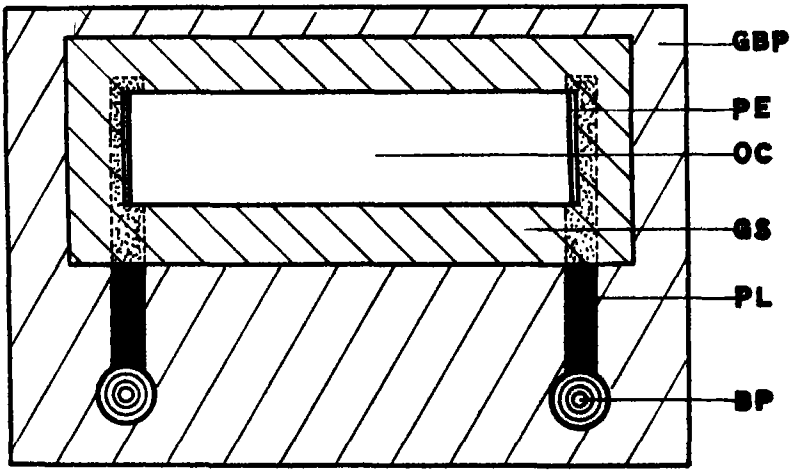

FIG. 1. Glass observation cell with platinum electrodes. GBP, glass back plate; PE, platinum electrode; OC, observation cell; GS, glass siding; PL, platinum leads; BP, binding posts.

We have reported in the above mentioned papers some galvanotropic responses of paramecia to balanced square waves. These studies were concerned with the relation of frequency to behavioral pattern when the current density "was sufficient to produce definite galvanotropism without any morphological distortion".

PROBLEM

In the behavior laboratory balanced square waves are applied as a means of electronic stimulation to a standard culture of *Paramecium caudatum.* This problem deals with the relation of thresholds to frequencies and current densities. At the threshold chosen the locomotor movements of the paramecia moving at right angle to the current appear normal, at the same time individuals whose long axis is parallel to current flow show an immediate avoiding reaction. This threshold is employed due to its minimum frequency grading, thus making mid frequency readings less variable.

APPARATUS

The methods for the production of balanced square waves applicable to behavioral studies were discussed by the authors in the previously cited papers.

For this study a glass cell of original design is utilized. (See Fig. 1.) This cell is rectangular; 28 mm long, 7.85 mm wide, and 1.58 mm deep. A full width platinum electrode is incorporated at both ends. In use, the paramecia culture fills the entire cell which is then covered with a coverslip.

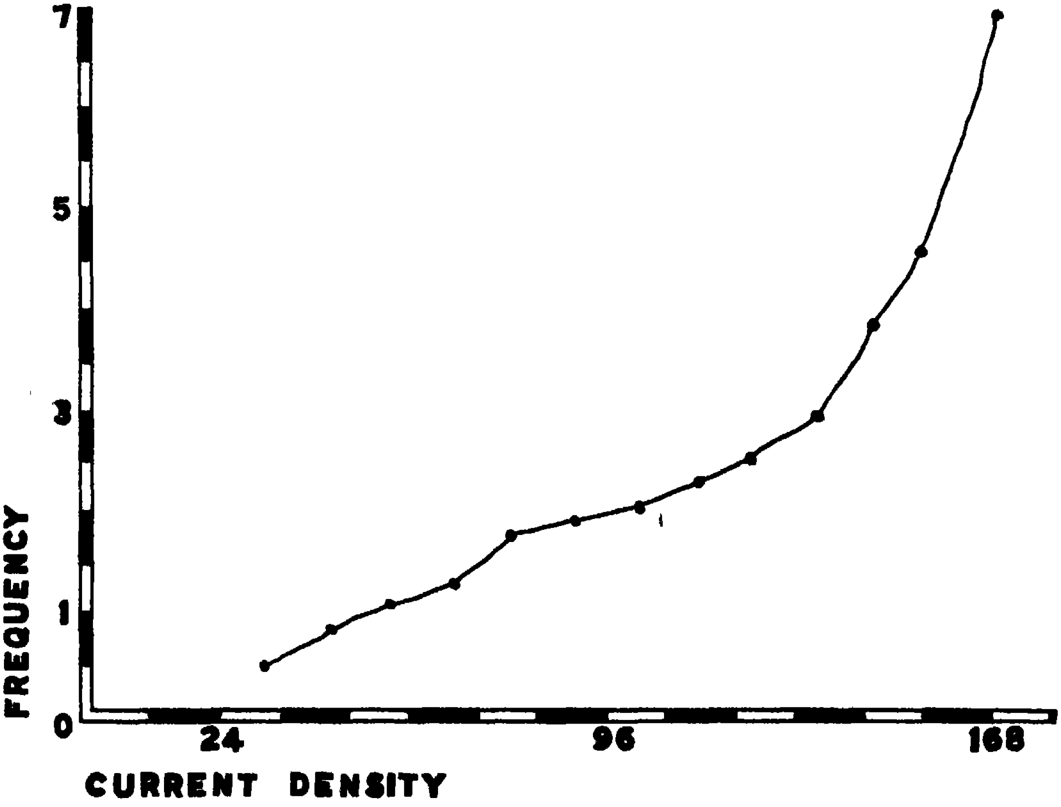

FIG. 2. Showing frequency in kilocycles per second and current density in microamperes per square millimeter necessary to produce responses discussed in text.

Frequency, balance, wave shape, and voltage (which is in direct proportion to current flow and current density) are checked at every step through the use of the direct deflection plates of an oscillograph. A calibrated audio frequency oscillator is employed to verify the frequency output of the square wave generator. Current levels are determined through the use of a microammeter for the various voltages.

The apparatus as described produces a form of electronic stimulation which can be quantitatively measured as to frequency, current, wave form, and voltage. The cell herein described further provides a volume of media the cross sectional area of which remains constant. With this apparatus it is possible to produce definite current densities at various frequencies. The current density is the microamperes passing in one direction through each square millimeter of the cross sectional area of the cell during one half the square wave cycle.

APPLICATION

Paramecium caudatum from the same culture source are subjected to the above mentioned form of stimulation. Frequent changes are made of the sample being tested. However, it is significant that with identical stimulation the reaction of the used sample is at no time different from that of the fresh sample. Room temperature of approximately 25°C prevailed throughout the testing period.

The amount of current passing through the observation cell is measured in microamperes. Current changes are made in units of 40 microamperes ranging from 420 to 2100uA (See Table I, column 1). The current density is then determined for each of the thirteen variables (See Table I, column 2). Within the range of each current density studied the optimum frequency to which the paramecia respond as noted previously, is determined and recorded in Table I, column 3.

Figure 2 illustrates the relationship between the two variables which interact to produce the studied response.

TABLE I

Microamperes Passing through Observation Cell	Current Density (uA/mm^2)	Mid Frequency for Threshold Noted. (c.p.s.)
420	33.9	600
560	45.2	800
700	56.5	1100
840	67.7	1300
980	79.0	1800
1120	90.3	2000
1260	101.6	2200
1400	112.9	2400
1540	124.2	2600
1680	135.5	2900
1820	146.8	3800
1960	158.1	4500
2100	169.4	7000

SUMMARY

Electronic stimulation in a variety of forms has been employed in behavioral studies. In this paper the authors describe the effect of balanced square waves at varying frequencies and current densities upon *Paramecium caudatum*. In this experiment a specific reaction is selected as a constant the variables being frequency and current density. The table and graph clearly illustrate that the frequency threshold for the selected reaction is determined by actual current density passing through the culture. In other words the same behavioral expression can be induced at different frequencies through the variance of the actual current passing through the organism.

In summary the responses of an organism to polarity interchange, in an electronic field, are determined not only by the frequency but also by the current density.

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GEOLOGY OF NEWPORT TOWNSHIP, WASHINGTON COUNTY, OHIO

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Columbus, Ohio

INTRODUCTION

Newport Township has an area of 36 square miles and lies within the Appalachian plateau physiographic province in the eastern part of Washington County, Ohio. The township borders the Ohio River, and lies just a few miles upstream from the city of Marietta, (see Geologic Map, Plate I). Geologically this township is of particular interest because it is here that the Burning Springs anticline of West Virginia crosses the Ohio River to form the Newell Run uplift of Ohio which is one of the most marked structural features in the eastern part of this State, and along which an important oil field is located.

Field work in the area was done in connection with the summer mapping program of the Geological Survey of Ohio during the summer of 1947, and a report on the geology of the township was prepared by the writer as a masters thesis at Ohio State University during the winter of 1947–8.

This paper is intended to bring out some of the more important facts concerning the structure and stratigraphy of Newport Township, gained as a result of the writer's geological work in the area. No previous geologic work in the township has been sufficiently detailed to clearly establish the structure of the Newell Run uplift, and to supply outcrop maps of the coal beds, details of their thickness and character, and intervals between the coals and other key horizons.

Rocks between the middle of the Conemaugh and the upper Permian are exposed within the area and comprise about 800 feet of strata consisting mainly of shales, sandstones, limestones, mudstones, clays, and coals. The nomenclature and correlation of these strata are shown by means of graphic sections on Plate II. The coal beds are mostly thin and of poor quality, but may offer more promise in the future as a source for synthetic fuels manufactured from low grade coal deposits. Other valuable deposits are the limestones and calcareous mudstones which contribute to the agricultural value of the soils. Abundant sandstone is present, but it is mostly of poor quality, and little use has been made of it up to the present. The Newell Run oil field, located along the uplift, has been active since 1890, and is still the center of considerable drilling activity, although not to as great an extent as in the past when the oil pools of this area supplied a major part of Ohio's petroleum production.

STRATIGRAPHY

Approximately 800 feet of strata is exposed in Newport Township. This includes the strata in the upper half of the Conemaugh series and all of the Monongahela series of the Pennsylvanian system. Rocks in the Dunkard series of the Permian system overlie the Pennsylvanian, and comprise the youngest deposits in the area. Following is a brief account of the stratigraphy and lithology of each of these series in the area under discussion.

CONEMAUGH SERIES

The Conemaugh rocks are exposed over an area of about three square miles near the crest of the Newell Run uplift. This structure brings to the surface the Cow Run sandstone and other middle Conemaugh rocks that are generally more than 250 feet below the level of the Ohio River in this part of eastern Ohio. Lithologically, the Conemaugh rocks consist mostly of sandstone, sandy shale, calcareous mudstone, thin beds of limestone, clay, and coal. The Ames limestone is exposed at the crest of the uplift, and represents the youngest known marine deposit in the section. Other important members in the Conemaugh deposits of the area are: the Harlem coal, the Elk Lick coal and limestone, the Clarksburg coal and limestone, and the Upper Pittsburgh limestone.

MONONGAHELA SERIES

Monongahela strata are exposed over the major part of the township, and the lithology of its strata is essentially the same as in the underlying Conemaugh except that there are more coal beds, and the strata are in general more uniform in character and interval. In Newport Township the Monongahela series contains shale, sandstone, mudstone, limestone, clay and coal. Of these the shales and sandstones comprise by far the largest proportion of the rocks. The limestones are few and thin, and the coals, with the exception of the Meigs Creek, which has been mined to some extent locally, are thin and of no value except as stratigraphic markers. The average thickness of the Monongahela strata in Newport Township is 240 feet, and the distribution of the rocks in this series is shown on the geologic map (Plate I).

Important marker beds in the Monongahela series are: the Pittsburgh coal and its overlying limestone, the Redstone and Fishpot coals, the Meigs Creek coal, the Uniontown coal, and the Waynesburg coal which comprises the uppermost bed of the series.

The extent and line of outcrop of the Pittsburgh coal, or where missing its horizon, marked by a disconformity at the top of the Conemaugh series, is shown by the black line representing the Conemaugh-Monongahela boundary on the accompanying map (Plate I) of this paper. Examination of the map shows that the outcrop of the Pittsburgh coal in Newport Township is restricted to a small area of about three square miles, where it is brought to the surface along the Newell Run uplift. In much of this area, especially along the axis of the uplift in Secs. 3, 4, and 33, ans along the west flank of Secs. 9 and 10, no trace of the Pittsburgh coal is found. In places the Upper Pittsburgh sandstone, or limestones that are normally found in the Pittsburgh coal–Upper Pittsburgh sandstone interval elsewhere in the township and throughout Washington County, rest disconformably upon the Upper Pittsburgh limestone. Where this situation prevails the Pittsburgh coal horizon was mapped at the contact of the Upper Pittsburgh limestone with the overlying Monongahela strata.

In Newport Township, and in general throughout the area of Monongahela outcrop in Washington County, the Uniontown coal is not of commercial value, but is a persistent formation and offers the most satisfactory single stratigraphic marker within the Monongahela series. It is for this reason that the structure contours on the accompanying geologic map (Plate I) are drawn on this horizon. The Uniontown coal varies within the township from a thin, carbonaceous streak to a coaly zone more than eight feet thick. These are, however, the extremes, and in the average section the coal zone has a thickness of one to three feet, the major portion of which consists of partings of various sorts. The most important factor contributing to the value of the Uniontown zone as a stratigraphic marker is its characteristic lithology. This very frequently is so pronounced that the geologist who is familiar with the section is able to locate his stratigraphic position in the field on the basis of the lithology of this coal bed without reference to any other members of the series; and often this may be done even where the coal is poorly exposed.

The two most distinguishing lithologic units found in the Uniontown coal member are: first, a coaly limestone often found near the center of the coal bed, and second, a hard, fissile, carbonaceous or coaly shale overlying the limestone. The limestone is usually black and coaly, fine-grained, often nodular or lenticular, and together with the overlying shale generally contains ostracod carapaces, which frequently are so profusely abundant in the rock that it might well be termed an ostracod coquina. The thickness of this limestone seldom exceeds 4 to 6 inches, and where the Uniontown coal zone becomes thin the limestone is generally wanting. The black fissile shale bed is found a few inches to one foot or so above the limestone bed, and is often persistent in exposures where the limestone is entirely wanting. It is a jet-black, fissile, coaly shale, that is characterized by its hardness and by its tendency to split into paper-thin laminae. Its great value as a marker of the Uniontown horizon lies in its resistance to weathering, and to the manner in which it splits up into thin laminae that cover the weathered slope of outcrops that would be extremely difficult to locate without the aid of these shale chips.

The Benwood limestone, in the lower half of the Monongahela series, may offer an important future source of agricultural lime to the farmers of the area, and the Lower Sewickley and Sewickley sandstones have limited local use. The remainder of the Monongahela series consists mainly of shale and thin-bedded sandstones.

DUNKARD SERIES

Rocks of the Washington group of the Dunkard series are present in all of Newport Township except in the area of the Newell Run uplift. Over the uplift they have been eroded while around the flanks of the uplift the Pennsylvanian-Permian boundary is near the hilltops, and dips to lower elevations to the north, east and west. The Pennsylvanian-Permian boundary is shown by the black line on the geologic map accompanying this paper, and the area underlain by Permian rocks is shown by the solid green color. The rocks in the Dunkard series are quite variable in thickness and lithology. There are sandstones, shales, limestones, and coal; these strata undergo rather rapid changes in facies, and contain few persistent marker beds. There is a preponderance of shale and thin-bedded sandstones that often are gradational one into the other. These lithologically similar beds occur in various stratigraphic positions, and make the Permian strata exceedingly difficult to classify and define. In the eastern part of the township where the rocks are relatively flat-lying the base of the Permian system is 130 to 160 feet above the level of the major streams, and about 150 feet below the hilltops. In the northwestern part of the township the strata rise due to the influence of the Cow Run uplift and the Permian rocks are found nearer the hilltops. In southwestern Newport Township and in southeastern Marietta Township, the rocks dip toward the Parkersburg syncline, so that in the extreme southwest corner of Newport Township, the Washington coal is found near stream level. This places the base of the Permian about 140 feet lower, and allows for 550 or more feet of Permian strata in the higher hills of that area. The rocks in the lower part of the Green group are, therefore, due near the hilltops in the southwest corner of the township, but outcrops in this small area are so few and so poor that no detail concerning the rocks of this group was obtained.

STRUCTURE

The area and extent of the Newell Run uplift and other structural features in Newport Township are shown by structure contours on the geologic map (Plate I). These contours give the elevation above sea level of the base of the Uniontown coal horizon, which is the most persistent, and the most widely distributed stratigraphic datum plane in the township. Examination of the map shows that the axis of the Newell Run uplift enters Ohio in the NW¼ Sec. 33, and extends north-northwestward into Sec. 11, where the structure flattens and dies out. The reader will note from examination of the map that the dips on the east flank of the structure are considerably steeper than those on the west flank where the strata dip to the southwest at a rather uniform rate of about 80 feet per mile toward the axis of the Parkersburg syncline. The Parkersburg syncline, which is a very prominent structural feature in West Virginia, extends northward into Ohio with its axis crossing the Ohio River near the eastern edge of the city of Marietta, 10 miles west of the axis of the Newell Run uplift.

Another prominent structurally high area in the township is located in Secs. 18 and 24, near the northern border of the township. This structural rise is due to the influence of the Cow Run uplift, the center of which lies on Cow Run about 1 mile north of the Newport Township line. Field work was carried on in the area of the Cow Run structure by Dr. A. T. Cross who did mapping for the Geological Survey of Ohio in that region during the summer of 1947. However, the mapping of this structure has not yet been completed, and for this reason, the northward continuation and the exact trend of the structural high in Secs. 18 and 24 of Newport Township cannot be very definitely predicted on the geologic map with this report.

There is a sharp change in the trend of the anticline at or very near the Ohio River where the structure makes a sharp swing from a northeasterly trend on the West Virginia side of the river to a northwesterly trend on reaching the Ohio side. The writer had previously thought it possible that this sharp change in the trend of the structure near the Ohio-West Virginia boundary might be present only in the upper strata, and that it might not be reflected in the deeper rocks. However, regional sub-surface maps prepared by the geological department of one of the major oil companies that has done considerable research in the area, offer convincing evidence that this abrupt change in trend is present, and that it is reflected in the rocks at least to the depth of the Berea sandstone. These maps, contoured on the Berea sandstone, show a structural trend similar to that shown on the geologic map (Plate I) included with this paper. The Berea sandstone was reportedly reached in drilling at an elevation of approximately 793 feet below sea level in the NW¼ Sec. 33, at the highest point on the Ohio structure. From this point the structure contours on the Berea sandstone indicate that the structure plunges northwestward in a manner similar to that shown by the structure contours on the map (Plate I) with this paper. The structural high on the Berea does not, however, plunge out to as great an extent as is indicated in the surface rocks, but rather it continues on, rising again to 1,070 feet below sea level on reaching the Cow Run uplift. From the Cow Run uplift northwestward, the Berea structure flattens into a broad low arch that continues to express itself in the structure contours until it reaches a point near the Washington-Noble County line. This northwest trend, shown on the structure map of the Berea sandstone, continues northwestward from the Newell Run uplift, through the Cow Run uplift, and northwestward to the Washington-Noble County line. This trend is nearly parallel to the trend of the Cambridge arch, and to the trend of the Parkersburg syncline, which are two of the major structural features in eastern Ohio.

Although detailed maps are not yet completed showing the structure of the Cow Run uplift as expressed in the surface rocks, it appears to have an essentially east-west axial trend. If this is correct then the trend of the Cow Run uplift is approximately at right angles to the northwest trend shown for the Newell Run uplift which, as expressed in the surface rocks, dies out on the west fork of Newell Run about 2½ miles north of the Ohio River, and two miles southeast of the Cow Run uplift.

ECONOMIC DEPOSITS

On the whole, there is little in the way of geological deposits except oil and gas in Newport Township that is of any commercial value. In the past, the coal beds have yielded some coal for local use, but they are not being worked at the present due to the thinness and poor quality of the deposits. These low grade coals may, however, be used at some future date in the production of synthetic fuel. Aside from the coal seams and petroleum products, the sandstones and limestones are the only other commercially useful deposits. There is a great deal of sandstone present in the township, but none is of much value for building stone or other economic use. There are no appreciably thick limestone deposits in Newport Township, and those present are in general too thin to be successfully quarried for use as agricultural lime or other purposes. A possible future supply of agricultural lime, which may be obtainable from the Benwood member, is suggested in the discussion of the limestone deposits.

COAL DEPOSITS

On the generalized stratigraphic section of Ohio (Plate II), are shown seventeen coal horizons that occur within the rock section exposed in Newport Township. Although all of these are not recognized, most of them can be identified, and the graphic sections on Plate II indicate those that are present and their correlation within the township. Of these the only ones that offer promise from an economic point of view are the Meigs Creek, Uniontown, and Washington, each of which will be discussed briefly.

The Meigs Creek coal was mined on Cow Run in the early days of oil exploration to furnish power for the steam drilling rigs, and is at present mined commercially at Moss Run located 1½ miles north of Cow Run, and three miles north of the Newport Township boundary. Along Bolivian Run in the S½ Sec. 6, Newport Township, there are several abandoned drift mines in which there was reportedly two and one-half to four feet of mineable Meigs Creek coal. None of these mines has been active since the depression years of 1930–1936, and it is reported that in these mines the coal bed was rather irregular, and that a number of clay rolls and cutouts were encountered in the mining. Over the major part of Newport Township the Meigs Creek does not attain sufficient thickness to be mineable, and in the area near Bolivian Run it is only of marginal mining thickness and does not warrant the effort necessary to get it out except during times of shortage or depression. It is therefore doubtful that the Meigs Creek deposits will ever warrant future development, except perhaps in connection with underground gasification projects that might be located in the Moss Run mining district a few miles to the north.

The Uniontown coal, which is found on the average of 110 feet above the Meigs Creek, is of no economic importance in Newport Township at the present time, although with the recent advancements in synthetic liquid fuels manufacture from low grade coals it is possible that in the future it may be of use as a source of raw material for this purpose. In the western half of the township exposures of the Uniontown indicate a thickness that would perhaps warrant analysis of the full zone of coal and coaly shales to determine their yield of oil per ton, after which coring would be advisable if the analysis proved favorable.

The Washington coal together with the Meigs Creek comprise the only two mineable coal beds in Newport Township. The Washington coal has been mined in the hill north of Long Run in the SW¼ Sec. 22 at an elevation of 928 feet. The mine is now caved in, but the owner reports that the coal bed attained a maximum thickness of forty-nine inches in this mine. He states, however, that the coal thinned rapidly after the drift entry had been driven twenty or thirty feet into the hill, and that because of the thinning the mine was abandoned. The rocks dip to the southwest in this area due to the influence of the Parkersburg syncline, which brings the coal nearer stream level in the southwestern corner of the township, where the Washington coal has also been mined in a small way for house coal. The coal is reported to have an average thickness of about two feet in these mines, but because of its thinness and poor quality it has never warranted commercial mining. The Washington coal generally has a high ash content throughout its extent in eastern Ohio, and those who have mined this coal in Newport Township state that although it is soft, it burns well, but leaves a great deal of ash.

SANDSTONE DEPOSITS

The sandstone deposits in Newport Township have not been found of much economic use up to the present. Unless the area becomes industrialized, and new uses are found for the sandstones, there probably is little chance that they will be used to any large extent in the future. Most of the sandstone deposits are rather soft and are either thin-bedded or shaly in character. Both of these factors detract from the value of the stone for building purposes. No quarries are known to have operated in the township, and about the only use made of the sandstone up to the present has been very limited local uses, such as for house and barn foundations, bridge abutments, and crushed rock for road building. For most of these purposes the stone at hand has been used and thus nearly all of the sandstones that outcrop within the township have been used at one place or another.

Sandstones in the Conemaugh series outcrop over such a small area that no particular use has been made of them. The Monongahela sandstones, which include the Upper Pittsburgh, the Lower Sewickley, the Sewickley, and at places the Arnoldsburg and Uniontown, have found more widespread use than the Conemaugh sandstones due to their greater distribution. Of these the Sewickley receives the greatest amount of use, but it weathers so rapidly that it is doubtful that any commercial use except perhaps sand manufacture could be made of it.

The Permian sandstones in Newport Township, which include mainly the Waynesburg and the Mannington, are either too flaggy, or else too soft to be of much value. The Upper and Lower Marietta sandstones come into the section along the Ohio River in the southwest corner of the township where they form prominent cliffs along the river bluff. Both of these sandstones are quarried extensively a few miles farther west near the city of Marietta, where the stone is used mainly for the manufacture of grindstones. The Marietta sandstones in Newport Township do not, however, attain the thickness and quality that they have near Marietta, and will probably not find use unless the Marietta deposits become depleted.

LIMESTONES DEPOSITS

In the exposed rocks of Newport Township there are only a few thin nodular beds of limestone, of which the Arnoldsburg is the only important one. There are, however, thick deposits of calcareous mudstone in the Lower Monongahela and in the Conemaugh that furnish abundant lime to the soil along their outcrop and that may offer a future source of agricultural lime for the township. The economic value of these deposits lies in their use as a source of lime for agricultural purposes, but little use has been made of them up to the present. However, there is a decided need for lime in most of the soils of the township, and an adequate supply of lime would add much to the economy of the area by permitting the raising of more alfalfa and other legume hay crops as well as other agricultural products that do best in well limed soil.

In general, the Arnoldsburg is not of sufficient thickness to be quarried out for crushing, and for this reason has not been used to any extent. One account regarding its use was cited to the writer by a farmer who gathered field stones weathered from the outcrop of the Arnoldsburg and had them crushed for agricultural lime. The Benwood member, on the other hand, has an extensive distribution over all but the southwest corner of the township, and attains a thickness of from thirty to sixty or more feet. It is a highly calcareous red mudstone containing small pellets of hard, white limestone. In the writer's opinion this mudstone may find extensive use in the future as a cheap and readily available source of agricultural lime.

In view of the abundance and availability of the Benwood member in Newport Township, a thorough study of it seems advisable in order to determine its acid neutralizing power and methods by which, if it proves to be of value, it might be mined and distributed to the farmers in the area.

OIL AND GAS DEPOSITS

Newport Township has long been important as an oil and gas producing area, and many hundreds of wells have been drilled there since the initial well was drilled in 1890. No complete record of the number of wells drilled in the township, or production figures, etc., concerning the many wells that have been drilled is known to the writer and it is doubtful if any such record has ever been maintained, although Bownocker[1] states that there were 300 producing wells in the township in 1900. The oil fields of the township are old fields that had their major development during the period between 1890 and the early 1900's. The area is, however, still active, and there are probably several hundred wells in the township that are producing at the present time. Most of these are old wells that only produce a few barrels a week, but are still worth being pumped. New wells are being drilled in the township, but seldom produce more than five to ten barrels a day, and are operated almost exclusively by individuals and small companies made up of local citizens.

The principal productive area in Newport Township is the Newell Run pool, located in the area of the Newell Run uplift, and extending northwestward into Sec. 13 of Independence Township. This practically unites the Newell Run pool with the Cow Run pool. There are also two other minor producing areas in the township. One is the Sand Hill pool, located principally in Marietta Township, but extending eastward into Secs. 33, 27, and 22 of western Newport Township, and the other is the Bosworth pool, located on the east side of the Newell Run uplift. There are also numerous other producing wells in the township that do not fall within the limits of either of the above three producing areas. These wells are scattered throughout the township and do not follow any noticeable trend or pattern.

The production in Newport Township is obtained primarily from the First Cow Run and the Berea sands. The First Cow Run sandstone belongs stratigraphically about in the middle of the Conemaugh series. It was the principal producing sand in the early days of the field, and is still producing in a number of wells. The up-dip of the rocks along the anticline brings the Cow Run sandstone above the level of the Ohio River near the mouth of Conley Run in the NW ¼ of Sec. 33, where a 29-foot cliff of the sandstone is exposed. From here the northwest plunge of the anticline carries the sandstone under cover where it is reported by Bownocker[2] to be struck at a depth of 300 feet on Peggs Run in Sec. 11, and at a depth of 478 feet on Eightmile Creek, in the NW ¼ of Sec. 18.

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[1] Bownocker, J. A., "Occurrence and Exploitation of Petroleum and Natural Gas in Ohio," Ohio Geol. Survey, 4th ser., Bull. 1, pp. 181-185, 1903.

[2] Bownocker, J. A., "Occurrence and Exploitation of Petroleum and Natural Gas in Ohio," Ohio Geological Survey, 4th ser., Bull 1, pp. 181-185, 1903.

The second Cow Run, or Priest sand, is found 400 feet below the First Cow Run. This sand is stated to be relatively unimportant, and to supply only a few productive wells in the township. Below the Second Cow Run, and above the Berea, there are several other sands that are occasionally productive at various places in the area. Among these are: the Salt sand, the Maxton sand, the Keener sand, the Big Injun sand, and the Squaw sand.

The Berea is now the principal producing sand in this area, and is the objective of most of the drilling being done in the township at the present. The Berea was reportedly found at a depth of 793 feet below sea level in a well located near the outcrop of the Cow Run sandstone at the mouth of Conley Run. This would place the well near the level of the top of the First Cow Run sandstone, and indicates an interval of approximately 1,400 feet between these two producing horizons in this area. The Berea is much more persistent than most of the shallower sands, and from a geological point of view, offers a very valuable horizon on which subsurface mapping may be done.

Production from horizons below the Berea has not as yet been successfully obtained in the area. Several deep tests, one reportedly over 7,000 feet deep, and forming one of the deepest tests in Ohio, have been drilled within a few miles of Newport Township, but have not been successful in obtaining production. To the best of the writer's knowledge, no deep test has yet been drilled on the Newell Run structure, but there reportedly is one currently being put down on the Burning Springs anticline at Volcano, West Virginia. If this well is successful in obtaining production from horizons deeper than the Berea, it will probably lead to renewed activity in the area and to the drilling of a deep test on the Newell Run uplift, in which case, the structure map (Plate I) with this report may prove useful by indicating the trend and closure of the structure as reflected in the surface rocks.

EARLY DEVELOPMENT OF THE HUMAN PHARYNGEAL HYPOPHYSIS — A PRELIMINARY REPORT[1]

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Most textbooks of Embryology and of Histology generally agree on the following more or less well-known facts: (1) the hypophysis or pituitary gland occupies a depression (the hypophyseal fossa) within the sella turcica which is located on the cranial aspect of the body of the sphenoid bone; (2) the hypophysis is a composite organ consisting of two main portions, an anterior and a posterior; (3) the anterior portion is further divisible into the pars distalis (or anterior lobe proper), the pars tuberalis and the pars intermedia, the posterior portion being designated usually as the neural lobe or pars neuralis; (4) three types of cells are recognizable in the anterior lobe; namely chromophobes, or reserve cells, which lack secretory granules, acidophiles, which contain alpha or acidophilic granules and basophiles, so-called because they contain beta or basophilic secretory granules; (5) the pars anterior is derived from the distal closed end of Rathke's pouch and the pars posterior arises from the infundibulum of the hypothalamic region of the diencephalon; (6) Rathke's pouch develops as a hollow epithelial diverticulum from the roof of the embryonic oral cavity or stomodaeum; (7) the original point of union of Rathke's pouch with the oral epithelium comes to be located well back on the roof of the primitive mouth, and still later when the palate separates off the nasal fossae from the oral cavity proper its site of origin lies at the postero-superior border of the nasal septum at its junction with the roof of the nasal pharynx; and (8) the distal end or hypophyseal portion of Rathke's pouch becomes separated from the stomodaeal epithelium by the obliteration of its original connecting duct or stalk.

Obliteration of the proximal connecting portion of Rathke's pouch with the oral epithelium is a gradual process. When the para-axial mesenchyme differentiates into embryonic connective tissue in the region of the future body of the sphenoid bone the connection of Rathke's pouch with its site of implantation to the epithelium becomes elongated and is gradually reduced to a narrow duct or stalk, which is termed the hypophyseal stalk or craniopharyngeal canal. When, later on, the process of chondrification takes place in the connective tissue, by means of which the cartilaginous body of the sphenoid is formed, the pharyngeal stalk is gradually compressed into a slender epithelial strand which is said to normally degenerate and disappear.

Most textbooks of embryology fail to give much detail concerning the origin and fate of Rathke's pouch and they dismiss the subject usually by merely stating that the stalk by which Rathke's pouch was attached to the stomodael epithelium completely disappears (2, 6, 10, 13, 14, 17, 18, 19, 21). On the other hand, some authors mention the occasional persistence of remnants of the connecting stalk of Rathke's pouch (1, 4, 7, 8, 11, 22, 24). Three typical sites of locations of these remnants have been described, namely "intracranial"—within the hypophyseal fossa adjacent to the hypophysis but separated from it by cranial dura mater, "interosseous"—embedded within the body of the sphenoid bone, and "pharyngeal"—within the soft tissue in the roof of the nasal pharynx. The term "pharyngeal hypophysis" is applied to the epithelial remnant in the roof of the nasal pharynx as opposed to the other two which are usually considered as a "persistent craniopharyngeal canal" (8, 22).

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[1] This investigation was aided by a grant from the Ohio State University Development Fund, for which the authors make grateful acknowledgment.

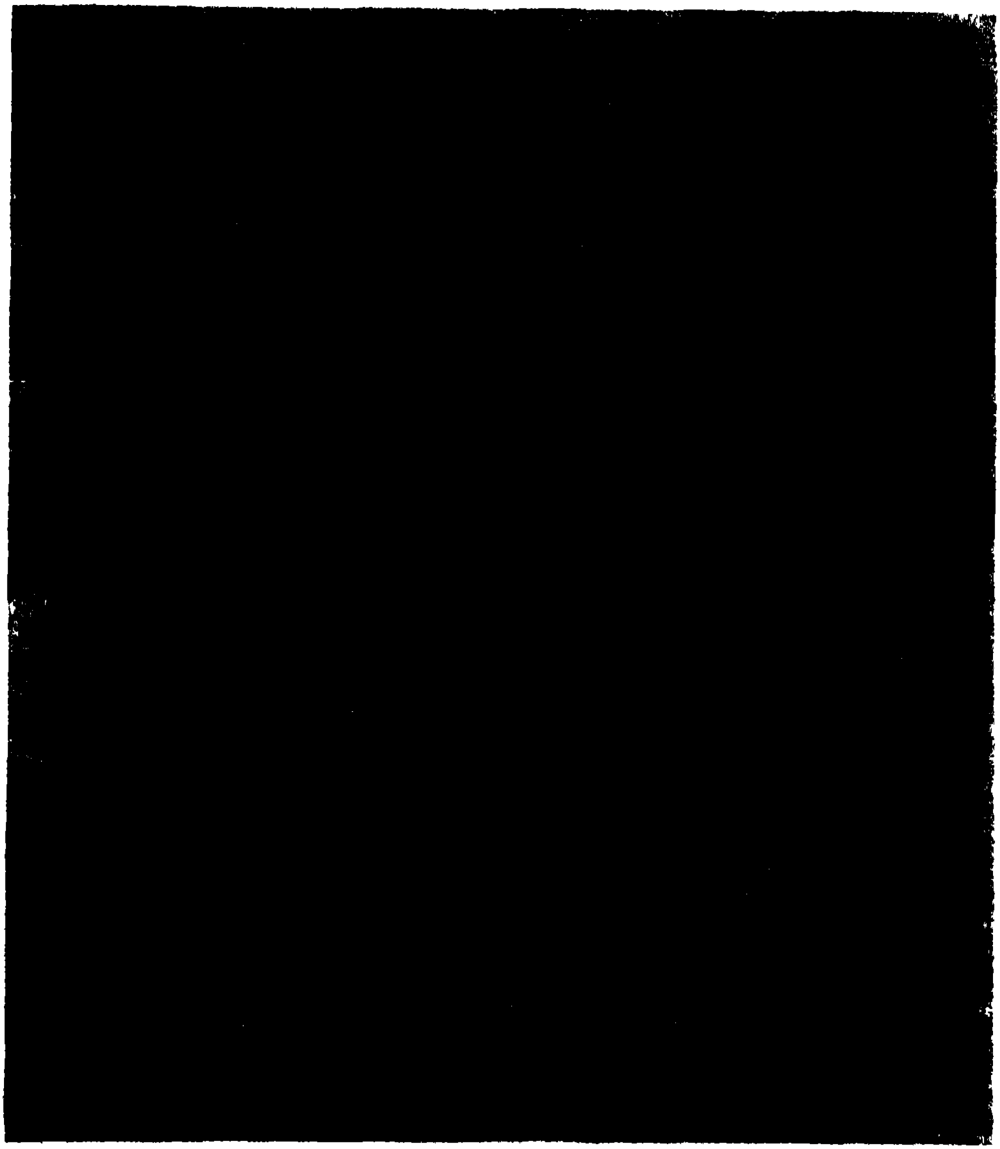
These epithelial remnants are generally considered to be anomalies or abnormalities. However, a few authors point out that the pharyngeal hypophysis is said to be constantly present (1, 4, 7, 22, 24). Thus, according to Smith and Copenhaver (24) "There occurs constantly in the vault of the nasopharynx, in man, a body of typical anterior lobe tissue. It has not been demonstrated in other species. This body lies in the midline and is elongated, its longitudinal axis being parallel to the sagittal plane of the body. It measures from 3.5 to 7 mm. in length by 1 mm. or less in diameter. The cells of the pharyngeal hypophysis are structurally identical with those of the anterior lobe and parallel them in their differentiation and development."

In view of the general agreement, among these outstanding embryologists and histologists, as to the constancy of occurrence of the pharyngeal hypophysis it seems strange that it is so frequently ignored in many textbooks of embryology, histology and human anatomy and that studies on its frequency of occurrence in the vertebrate series and on its histogenesis in man and other species have been so generally neglected. Aside from scattered reports in the literature concerning its involvement in neoplastic growths, which would appear very likely, surprisingly few papers bearing on its frequency in man and lower animals and on detail studies of its development have appeared. Haberfeld (9) reported the results of his studies on its development in a few human fetuses including the newborn; Christeller (5) reported its normal and pathological appearance in adults and in 1938 there appeared for the first time in the English literature a report of its occurrence in human autopsy material. This was by Melchionna and Moore (20) who found it in 51 out of 53 unselected autopsied bodies which they studied, ranging in age from the newborn to 69 years. These authors claimed its cellular constituents were histologically identical with those in the pars anterior of the hypophysis except the differentiated cells were relatively fewer. Hertwig (11) claimed that in many vertebrates, e.g. Selachians, the pharyngeal stalk is retained throughout life as a hollow canal which perforates the base of the skull and is united with the oral epithelium. Kingsbury (15, 16) made a detail study of it in the dog in which he claimed it occurred in almost 100% of the cases examined and mentioned that it had been reported seen in the cat (3) and rabbit. Its presence in the rat (23) and ox (12) however, has been denied.

Inasmuch as so few studies have been made of this structure, and in view of its possible involvement in pathological conditions of the hypophysis and possibly other endocrine organs, the authors have launched upon a research program to investigate its frequency of appearance in man and other vertebrates, its histogenesis and fate and eventually to determine whether or not pathological conditions or experimental procedures may affect it in any way. The present report on its early development in man is the first to come out of this projected study.

In a six mm. (about four weeks) human embryo Rathke's pouch is well defined (Fig. A). It appears in a sagittal section as a finger-like epithelial diverticulum in close relation to the floor of the fore-brain and with a narrow, slit-like lumen opening inferiorly into the oral cavity. However, in a transverse section at this stage it is, in reality, wide and flattened.

By the 12 mm. stage (about five weeks) the continuity of Rathke's pouch throughout its length is broken, its distal free end, which is destined to differentiate into the pars anterior of the hypophysis, is enlarged and its proximal end persists for some distance and retains its connection with the oral epithelium (Fig. B). Condensation of the mesenchyme in the area intervening between the remaining portions of Rathke's pouch (4 and 5) indicates the beginning of chondrification of the future body of the sphenoid and may explain the constriction of the neck of the



Photomicrographs of sections of human embryos showing stages in development of the pharyngeal hypophysis.

A. 6 mm. Human—Sagittal section—Mag. 84×—H. & E.
B. 12 mm. Human—Sagittal section—Mag. 81×—H. & E.
C. 22 mm. Human—Cross section —Mag. 387×—H. & E.
D. 25 mm. Human—Sagittal section—Mag. 44×—H. & E.
E. 50 mm. Human—Sagittal section—Mag. 778×—H. & E.
F. 80 mm. Human—Sagittal section—Mag. 84×—Hem. & Orange G.

1. Rathke's pouch.
2. Oral cavity.
3. Fore-brain.
4. Pharyngeal hypophysis.
5. Pars anterior of hypophysis.
6. Nasal pharynx.
7. Infundibulum.
8. Basi-sphenoid.

pouch. The persistent site of implantation of the proximal end of the pouch is the primordium of the pharyngeal hypophysis.

Figure C shows a magnification of the pharyngeal hypophysis (4) in a 22 mm. (about eight weeks) human embryo. The epithelial cells composing it are undifferentiated, although they exhibit evidence of elongation and proliferation at the site of implantation on the free surface of the oral epithelium. The persistent stalk is surrounded by mesenchyme with the exception of its periphery where a connective tissue capsule is differentiating and an embryonic blood vessel is making its appearance at its free distal extremity.

In an embryo 25 mm. in length (about 10 weeks) the future body of the sphenoid is cartilaginous, the sella turcica is outlined and is occupied by the future hypophysis, the pars anterior of which shows vesicle-formation, and the pharyngeal hypophysis is well marked and distinguishable from the surrounding cells, its original direction with respect to the differentiating pars anterior of the hypophysis being maintained. By this stage the palate has formed and the original site of attachment of the pharyngeal hypophysis to the epithelium of the primitive, oral cavity has shifted caudally (rather the head has grown forward from that point) so that it now lies in the roof of the nasal pharynx, where its presence has been described in the adult stage (5, 9, 20).

No evidence could be found in the present series of human embryos of the beginning of cellular differentiation in either the future hypophysis or the pharyhgeal hypophysis until the 50 mm. stage (about 12 weeks), at which time (Fig. E) the cellular constituents of both (4, 5) were almost identical and consisted of two types, one type having an oval, vesicular nucleus with relatively sparse, more or less colorless cytoplasm and the other type having a smaller, rounder and more darkly staining nucleus with more abundant, and slightly acidophilic, cytoplasm.

The oldest human embryo included in the present study was an 80 mm. (about 14 weeks) stage (Fig. F). As can readily be seen from the photomicrograph the pharyngeal hypophysis is well marked and, in comparison with previous stages, has undergone considerable hypertrophy and is quite vascular when examined under high magnification. Cellular differentiation in the pars anterior and in the pharyngeal hypophysis showed little advancement over the 50 mm. stage. A cursory examination of stages 115 mm (about 4 months), 138 mm.(about 4½ months) and 160 mm (about 5 months) revealed its presence and to be undergoing continued hypertrophy and increased vascularity.

Further studies of the fate of the pharyngeal hypophysis in older human embryos are in progress and will be reported in the future.

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THE USE OF THE MALE FROG TEST AS AN AID IN THE DIAGNOSIS OF RETAINED PLACENTAL TISSUE

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In a previous article (1) we pointed out the value of the male frog, ***Rana pipiens***, as a ***new test animal*** for early pregnancy. As the number of tests increases, it still is nearly one hundred per cent correct in the first trimester of pregnancy. The more recently published work of Robbins and Parker (2) substantiates our results and clinical laboratories throughout the United States are using this test in increasing numbers. Information regarding the storage, handling and feeding of the frogs has been published in another article (3).

A New Use For the Test

During the experimental work on the male frog pregnancy test we ***discovered a fact which is of great clinical importance.*** It was suggested by the following history.

Case History: Mrs. R. W.—On January 5, 1948, Mrs. W. awoke at 2:00 A.M. and found that she was bleeding par vaginum. After some cramp-like pains she passed several large clots. The clots were examined and one was found to contain a small foetus measuring about 4 Cm. in length. There was no more bleeding. The first specimen of urine the next morning (January 6, 1948) was injected into two males frogs. The test was positive even though the foetus had been passed. The patient was treated conservatively; bed rest, soft diet, sedatives and Ergotrate tablets (gr. 1/320 tid). The pulse and temperature remained normal. Bleeding was slight, patient remained in bed.

On the morning of January 8, 1948 cramps and vaginal bleeding, which was more than normal in amount, occurred. The patient was hopitalized. Vaginal examination revealed a soft uterus, the cervix was dilated two finger tips and the placenta, though partially extruded, ***was still adherent to the posterior wall of the lower uterine segment.*** Digital removal of the placenta was not attempted. Intravenous Ergotrate did not cause the expulsion of the retained placenta. On January 9, 1948, the first morning specimen of urine was injected into two male frogs. ***The test was still positive.*** At noon on January 9, 1948, the patient was sent to the operating room and a dilatation and currettage was performed. A placenta measuring 7 cm. in diameter was removed, the uterus carefully curretted and packed with sterile gauze. The first postoperative urine specimen, voided at 8:00 P.M. January 9, killed two male frogs before the test could be completed. The first morning specimen voided January 10, 1948, ***eighteen hours after the placenta had been removed***, was injected into four frogs. All four ***frogs were negative.*** The first morning specimens of urine for the next two mornings were injected into frogs and the test were ***negative*** on both days. The uterine pack was removed at the end of twenty-four hours. Recovery was uneventful. The patient was discharged in good condition.

From this case we inferred that:

1) The pregnancy test on the male frog (***Rana pipiens***) ***is positive as long as there is live placental tissue still adherent to the uterine wall.***
2) The hormone which is responsible for the positivity of the male frog test is ***produced only by the live attached placenta*** and, therefore, should be called the "gametokinetic placental hormone". Such a hormone may prove to be useful in cases of infertility.

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Due to the ease, accuracy, and rapidity of the test we assumed that it could be used clinically in obstetrics as well as for the diagnosis of pregnancy. Consequently, one of us (Pickett) undertook the testing on male frogs of a series of cases at White Cross Hospital, Columbus, Ohio. While the number is not large, the results consistently demonstrate the fact that the above inferences were correct.

Investigations Undertaken

1. Every case of therapeutic abortion was to have a male frog test run both preoperatively and twenty-four hours postoperatively.
2. If possible every dilatation and currettage was to have a male frog test run preoperatively and postoperatively.
3. All cases of threatened abortion, inevitable abortion and missed abortion which were admitted to the Department of Obstetrics were to have a male frog test performed on admission and repeated, if it was suspected that there was retained placenta either attached to the uterine wall or unattached.

This procedure was followed in a series of nineteen cases.

Conclusions

1. There was only one case of therapeutic abortion in the series. The patient was hospitalized, the urine was tested on male frogs both before and after surgery. The frogs tested *positive* preoperatively and they tested *negative* twenty-four hours postoperatively.
2. There were eighteen cases of known pregnancy in which there were signs, such as nausea and vomiting, associated with cramps and vaginal bleeding or "spotting" either continuous or intermittent. Male frog tests were run on these cases. Four of them were inevitable abortions. The frog tests were *negative* before the foetus aborted. Six were "missed abortions". The frog tests were negative and the patient either was subjected to a dilatation and currettage or, if clinically improved, they were treated conservatively. *There were six cases of this kind in which the frog tests turned out positive.* These cases were considered to have the *placenta still attached* and all six were subjected to supportive treatment and bed rest. All six are *still pregnant* and in good condition. These were diagnosed *threatened abortion.* Without this test some of these surely would have been subjected to surgery and the baby lost.
3. The *missed abortion* cases, many of which would have been kept in bed for several weeks and treated expectantly, were curretted and were discharged improved in several days. The pathology reports on all such cases showed that an abortion had taken place.
4. It is believed that these cases show that the original inferences were correct and that the male frog test can be used to diagnose the detachment or death of the placenta thereby putting the differential diagnosis between "threatened abortion" and "missed abortion" on a much firmer basis and saving many babies which would have been lost through surgery.

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MYRMECOLOGICAL TECHNIQUE

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III. DDT Too Perfect an Ant Killer for the Collector's Use

For several years the writer has used ether in collecting ants but for cigarette smokers ether has the hazard of explosion. The forgetfulness and excitement accompanying the discovery of a nest of strange ants, if made while smoking, could permit the explosive mixture of ether and lighted cigarette. The ants would be in the nest opening and probably recoverable, but the collector on the free side of the explosion might be found to be of little immediate use.

In August of the past season at the University of Michigan Biological Station store we obtained an "aerosol bomb" of the pressure atomizer type and tried it on a nest of *Formica sanguinea aserva* Forel. This was a young nest with a mixture of the host ant *Formica fusca subsericea* Say. (This "slave-maker" has no slaves but the *sanguinea* queen enters a *subsericea* nest, makes friends and lets the latter rear her early brood until such a nest may be half full of red ants. Such nests are in the ground, the site for *subsericea*. Later the *aserva* queen and workers move to a log or stump, if available.) The nest was opened with a shovel and the aerosol directed onto the scampering ants. The latter did not drop dead at once but after a moment or two of slowing down died rather promptly. The mixture of yellow sand, black top-soil and gravel acted as a concealing background for the red and black *aservas* which had dark head, red thorax and black gaster. Right before our eyes they disappeared. By close scrutiny enough were recovered for identification but the special effort and extra time needed to obtain specimens relegated the aerosol bomb to the back seat of the automobile to be used later on cabin pests.

We had uncovered a collecting method which was too good. In collecting a method must be used in which the ants are merely slowed down but are not completely inactivated. A cool day, 40° F. to 60° F. is the best inactivator for most species. A moderate dosage of ether is the second best. The ant must be able to move at least a leg or antenna to be readily seen by the collector if it is on a continuous background of the usual nest debris of finely mixed colors. A collector soon learns the best dosage of ether to allow the recovery of completely etherized ants within a length of time useful in collecting. If the mixture of ants and nest debris is rolled or sifted so that artificial respiration is induced in the very lax sleeping ants they may recover at surprising speed and need a second etherization. Recovery varies greatly with temperature, slowly on cool days and with distressing speed in the hot sunshine when ether flashes dry almost instantly.

Thus ether is within the control of the collector while DDT and its mixtures with pyrethrum kill ants almost at once with no further help from struggling sleepy victims. The ant must move, even quite large species, to be seen easily. A dead ant does not move against the contrast of motionless soil. The contrast of a wiggling leg or even ant foot against a motionless background is the key principle of visibility. In the case cited, that of *aserva* the dark minors were especially difficult to locate.

In an earlier paper, Myrmecological Technique, II, we cited cyanide dust (Cyanogas) as a collecting aid for tree and bush ants. This also kills but the ants fall out of the background (tree or bush) onto a white cloth where they are easily found.

Thus DDT and its mixtures are too good in slowing ants down to a pace that renders them most easily collectable. We have tried it on only this one species. The can of mixture used was labeled the "Superla Junior Aerosol Automatic Atomizer with DDT," manufactured by the Standard Oil Company, Chicago, Ill. It contained 2.00% (a light dose) DDT, 0.25% pyrethrins and 5.75% methylated naphthalene as killing agents.

THE SIGNIFICANCE OF BLEEDING IN EARLY PREGNANCY AS EVIDENCED BY THE MALE FROG PREGNANCY TEST[1]

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The above title was taken from an article by Rutherford, published in 1942 (1). The words "male frog pregnancy test" have been substituted for "decidual biopsy."

Wiltberger and Miller in early 1948 presented a simple method for the test of the early diagnosis of pregnancy. A few months later the same method was reported by Robbins and Parker (2). The test reported by these men may be performed by any practitioner in his office, home, or hospital. It is simple to do, is accurate and inexpensive, (3). Secondly, it may be used to differentiate between threatened and incomplete abortion.

The threatened abortion rate is 16 per cent or higher, (4). If it were possible to differentiate between the patients with inevitable abortions and those with threatened abortions, the attending physician could manage each patient more intelligently. The patients with inevitable or missed abortions, if diagnosed early, would be saved long periods of bed rest and valueless medication. Patients evidencing threatened abortions would receive proper treatment, and a pregnancy which might otherwise have been lost, either from lack of therapy or by the institution of active treatment to evacuate the uterus, might be salvaged.

In the majority of cases the male frog pregnancy test differentiates in a short time between threatened abortion and inevitable, or missed abortion. In some patients the test is negative almost immediately after the onset of uterine bleeding, but becomes positive again within twelve to twenty-four hours. Hence, in the absence of cervical effacement, dilatation, and excessive uterine bleeding, conservatism may be employed and the test repeated.

While waiting to repeat the test, any of the accepted forms of anti-abortive therapy may be carried out. If the second test is negative, only twenty-four hours, at the most, will have been lost by the patient. If the second test is positive, she has been given every possible chance to continue her pregnancy.

---

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We have used this test in 16 patients presenting the symptoms of threatened abortion, viz., cramps and uterine bleeding, or spotting. In six of these patients we found that the abortion was threatening only, and prompt anti-abortive therapy produced a continuation of pregnancy. By the test ten patients were found to have either inevitable or missed abortions, and they were treated accordingly. In these patients the test was always repeated at least once in a period of 12 to 24 hours.

One of the big advantages of the male frog pregnancy test is the rapidity with which the test becomes negative after the abortion becomes inevitable. With the Ascheim-Zondek or the Schneider-Friedman tests, the persistence of the positive reaction does not necessarily imply that the embryo is still living, (5). The pregnancy reaction may persist 7–10 days after the termination of a pregnancy. In the male frog test it becomes negative within 10–12 hours, (6).

We believe that by the use of the male frog pregnancy test any physician, without the help of any laboratory test except that which he himself can perform, may make a differential diagnosis between threatened abortion, and inevitable or missed abortion, within a period of time varying between two and twenty-four hours.

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